Heraeus

Heraeus Dental Science

Venus® Diamond
Venus® Diamond Flow
Scientific Compendium

Experts in dialogue.

Preface

After five years of continuous development the universal nano hybrid-composite Venus Diamond® from Heraeus has been available to dentists.

The invention of new innovative products is always a protracted process which several ups and downs. But set-backs also stimulate new developments and enable breaking new grounds. Progress is possible only by doing things in a different way.

The development of Venus Diamond started with a survey in different countries to identify what dentists expect from a perfect composite.

Low shrinkage, stable consistency and improved gloss stability were identified as the main demands by the dental practitioners.

In the following our scientists translated the ideas into practice by intensive research. While this process construction principles and building blocks of the well-known composite technology had to be completely reinvented.

On the subsequent pages we will illustrate the history and the chemical background behind the new VENUS nano hybrid composites to allow you to understand why these materials are the Diamond Class of composites.

To give further evidence on the outstanding material properties of Venus Diamond and Venus Diamond Flow various study results are summarized in this compendium.

We kindly invite you to test Venus Diamond and Venus Diamond Flow by yourselves.

Dr. Andreas Utterodt
R&D Manager for Composites
Heraeus Kulzer GmbH, Wehrheim, Germany
andreas.utterodt@heraeus.com

Dr. Janine Schweppe
Scientific Affairs Manager
Restoratives & Impressions International
Heraeus Kulzer GmbH, Hanau, Germany
janine.schweppe@heraeus.com

Content

Introduction

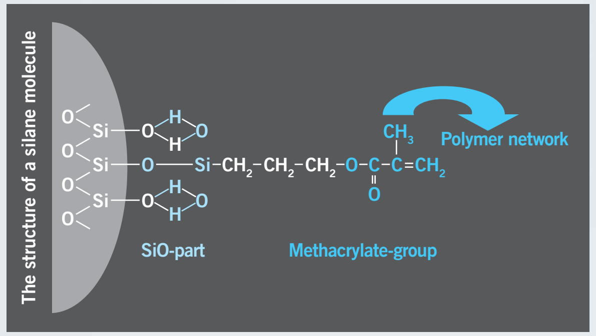
The wish to be beautiful and healthy is as old as mankind. Beautiful and harmonious teeth are a calling card and perfect aesthetics in restorations are becoming a key factor for patients when choosing their dentist.

Composition of composites

The discovery of the potential of Bis-GMA as crosslinker for dental materials by Prof. Bowen in 1962 was the starting point of the development of direct tooth coloured filling materials. This crosslinker was a mile stone in the beginning of modern restorative dentistry: For the first time dentists were enabled to prepare minimal-invasive and tooth-coloured restorations with the introduction of micro-filler composites in the 80s.

The term "composite" actually only refers to the fact that the material is composed of several components, i.e. at least 2 different phases (e.g. monomers and fillers). According to this broad definition, glass-ionomers, compomers, resin-based composites and ormocers are included in this group. They all have something in common – they cure to form a polymer network with glass, quartz or ceramic filler particles embedded in it.

In the narrow sense, "composite" is used to describe resin-based composites – this is what is meant when the following text refers to "composite". Composites are based on polymerisable monomers (e.g. Bis-GMA, TEGDMA, ormocer monomers, UDMA) reinforced with various sizes and types of filler particles. Inorganic fillers have to be added to the monomer system to attain the degree of strength which enables resin based composites to be used in stress bearing posterior areas.



The filler particles are not only bonded mechanically to the monomer matrix, they also undergo chemical bonding with it. These molecules – called silanes due to their chemistry (word made up from Silicone and Methane) – exhibit two different functional groups. On one side, the silane molecules react with the SiO groups on the surface of the filler and are polymerised into the growing network via the methacrylate group on the other side of the molecule.

The reinforcement of the filler particles depends on their chemistry (e.g. silicic acid, quartz or glass filler particles) as well as the particle size and distribution. In general, the harder and larger the particles, the higher the strengthening effect (but: the worse the polishing properties). Only the correct combination of different filler particle fractions produces optimum mechanical and polishing properties. Composites are categorised according to their viscosity, basic chemistry, curing mechanism or the size of the filler particles used. The most common type of classification involves the filler particle sizes – it actually mirrors the "evolution" of composites over the last decades.

The beginning – Macrofillers

First milestone during the development of resin composite materials were macro filler composites in 1965. Filler particles with filler sizes between 10–100 µm were added to the resin matrix.

These macro filler composites had the advantage of an increased strength and suitable shrinkage level. But the bigger filler particles were much more prone to abrasion and a sufficient aesthetics was not achievable. How has the abrasion worked? The glass of each filler particle has optimal mechanical properties as a solid body. Within the composite (reinforced polymer) these particles are embedded into a "softer" matrix. Due to the size of these grand filler particles the wide space between the fillers was filled with matrix only.

Introduction

Small abrasive food substances could abrade the "exposed" matrix easily until the filler particle was lost. Due to the size of the lost single filler particle the surface roughness of the restorations increased dramatically like a rough coastline.

Abrasion principle in macro filler resin composites

Aesthetic revolution – Microfiller composites

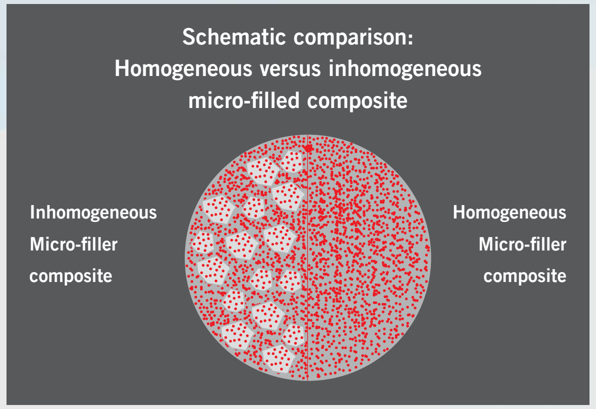
The next milestone in the evolution were the micro filler composites which were introduced in 1974.
Very easy polishing and remarkable aesthetics are their main characteristics. As the name micro filler indicates the size of the inorganic filler particles is very small (0,04 µm). Due to the small size of these agglomerated filler particles, micro-filled composites can be polished to a long-lasting and excellent luster and their smaller surface area helps prevent the filler particles being dislodged from the matrix. This can be seen clearly in the picture of an historical footpath: People have been walking over it for 500 years: all filler particles have been polished to a high lustre but none have been dislodged.
This prevents large "potholes" forming (as described before).

A historical footpath in Teguise, Lanzarote – shows the micro-filled composite principle

However, the advantages of smooth surfaces and improved wear properties are gained at the expense of considerably reduced fracture toughness. As the surface area of smaller filler particles is larger in comparison to their volumes, they cannot fill to such a high density as macro-filled composites. This leads to higher polymerisation shrinkage.

Those micro-filled composites containing solely fumed silica filler particles are called ho-mogeneous micro-filled composites.

A new technical method, developed by Heraeus Kulzer at the end of the 70's, was used to increase the filler content despite this: finely milled, pre-polymerised micro-fillers were added to micro-filled composite in addition to the pure inorganic SiO_2 fillers.



Homogeneous micro-filled composite was turned into heterogenous (inhomogeneous) micro-filled composite, which contained pre-polymerised micro-filled composite constituents in the form of "organic macro-fillers". This enabled the polymerisation shrinkage to be reduced to an acceptable level but without compromising the excellent polishing properties and elasticity. The heterogenous micro-filled composite concept has been proven for anterior restorations and still applies today. Durafill® VS composite is a classic member of this group – it has been used successfully in clinical practice for almost 30 years.

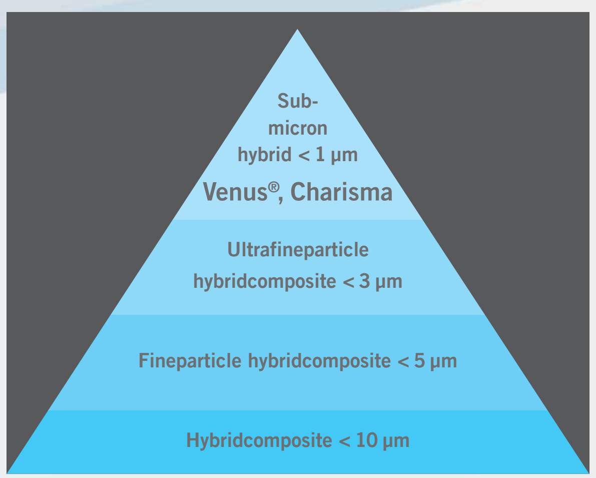
Despite this, one has to admit that even heterogenous micro-filled composites are not strong enough to be placed in regions exposed to masticatory loading.

These disadvantages limited the usage of micro filler composites to anterior restorations. Hence, efforts were made to develop materials which can be used also for posterior regions.

The best of two worlds – Hybrid composites
During the following years the development was focused on the combination of the advantages of micro- and macro filler.

Principle of hybrid composites

Hybrid composites which are containing a mixture of different sizes of fillers were born. These composites were developed for universal use: anterior and posterior restorations could be made from the same material.



Hybrid composites are classified by the mean particle size. Charisma and Venus are representatives of this material class as a typical sub-micron hybrid composites.

Those materials resists high mechanical loading due to the macro fillers and show simultaneously an excellent polishing behaviour based on the limited maximum filler size. The packaging density is also increased which improves additionally strength and shrinkage of the materials.

For highest aesthetic demands – nanooptimised composites
In the last decade nano particles were added to hybrid composites and also nano hybrid composites were developed. Nano filler composites are also a sort of hybrid composites but instead of using a milled glass filler fraction agglomerated nano cluster are used.

Nano particles are smaller than 100 nm. The advantage of adding nano scale particles described for most of the composites is the improved filler packing density. Shrinkage is reduced whereas strength and wear resistance is increased.

In Venus Diamond the main advantage of the addition of nano particles is an improved aesthetical appearance of the restoration. On the one hand discrete nano particles (not agglomerated) improve the translucency of a resin composite. They are smaller than the wavelength of visible light and are hence invisible for the human eye. This increases the translucency of the material which optimises the so called chameleon effect of the filling material.

On the other hand nano particles improve the polishing of the restoration. The luster is stable for a long period of time.

The addition of nano particles led to more resistant and aesthetic restorations. But still one problem of resin composites remained untouched: the shrinkage and shrinkage stress reduces the longevity of restorations.

Minimising an old problem – Low shrinkage composites
Therefore, the development of low-shrinkage composites came recently into the focus of dental manufacturers. Every resin composite shows certain shrinkage during polymerisation.

Several solutions were created to reduce the shrinkage problem: the usage of different matrix chemistry (e.g. Filtek Silorane, 3M ESPE), elevation of filler load (e.g. Grandio, VOCO), increased weight and length of crosslinkers (e.g. Kalore, GC) or decreased crosslinking density (e.g. ELS, Saremco). But these actions have mostly not a direct related impact on shrinkage stress.

A composite in a bonded cavity does not have the ability to shrink freely[1]. Therefore, shrinkage stress due to pulling forces within the composite and on the interface restoration-adhesive- tooth arises during the blue light induced polymerisation.

Shrinkage stress which is influenced by further factors like rheological flow properties of the unpolymerised composite and rigidity of the cured material lead to crucial problems for the longevity of a dental restoration. Tooth integrity can be affected by hairline cracks, cusp deflection or even fracture of cusps. Also, marginal integrity can be influenced negatively by a high shrinkage stress: marginal gaps, staining or even secondary caries and postoperative sensitivity can occur as consequence[2,3].

Some of the modern low shrinkage composites are optimised to exhibit a low shrinkage and/or low shrinkage stress, but not all of them showing excellent mechanical properties.

Low shrinkage stress and high mechanical stability – Venus Diamond
Secondary caries and fractures are the main failure reasons of resin composites in the last years[4]. Therefore, modern composite restoration materials also need to have an excellent mechanical performance.

Those considerations led to the development of Venus Diamond which is a universal composite resin with outstanding low shrinkage stress and mechanical properties.

The corresponding flowable composite Venus Diamond Flow was also created following the principle of a reduced shrinkage stress combined with a high mechanical stability beside the excellent flow behaviour.

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[1] Braga RR, Ferracane JL: Contraction stress related to degree of conversion and reaction kinetics. Dent Res. 2002 Feb;81(2):114-8.

[2] Bausch JR, de Lange K, Davidson CL, Peters A, de Gee AJ: Clinical significance of polymerization shrinkage of composite resins. J Prosthet Dent. 1982;48(1):59-67.

[3] Tandbirojn D, Versluis A, Pintado MR, DeLong R, Douglas WH: Tooth deformation patterns in molars after composite restoration. Dent Mater 20 (6), 2004:535-542

[4] Bernardo M, Luis H, Martin MD, Leroux BG, Rue T, Leitão J, DeRouen TA: Survival and reasons for failure of amalgam versus composite posterior restorations placed in a randomized clinical trial. JADA, 2007, 138 (6): 775-783.

Venus Diamond is a new nano-hybrid universal composite that combines low shrinkage stress and excellent strength in a unique way. This material can adapt perfectly to the colour of the surrounding tooth structure and features an outstandingly natural look.

These outstanding features are caused by the new diamond formula which is based upon a new cross linker chemistry and an optimized filler system including special silica nano particles.

Composition of Venus Diamond at a glance

Monomers	TCD-DI-HEA and UDMA
Fillers	80–82 %-m (63,5–65,1%-vol) filler Range of filler particle size: 5 nm–20 µm Barium Aluminium Fluoride glass Highly discrete nanoparticles
Further ingredients	Rheology modifier, initiator system, stabilizers, pigments

Indications

Venus Diamond offers all features one is looking for in a single composite. For this reason Venus Diamond can be used for various indications:

- Direct restoration of Class I–V cavities
- Direct composite veneers
- Aesthetical corrections of teeth (i.e. diastema closure, repairing of congenital defects in teeth, etc.)
- Temporary splinting of teeth loosened by trauma or periodontal disease
- Indirect restorations (inlays, veneers)
- Restoration of primary teeth
- Core build-up
- Repair of porcelain and composite restorations (in combination with an adequate repairing system)

Chemical Background and Advantages

The Diamond Formula

A patented matrix and a newly developed nano-hybrid filler system lead to improvements in aesthetics, durability and handling: Venus Diamond is based on novel urethane cross-linkers including the special low shrinkage TCD-DI-HEA.

During the last decades of composite development the main progress was done in the filler system. Only few efforts were made to design new matrix systems.

Therefore, the majority of modern composites rest upon the 50 years old Bis-GMA-cross linker matrix.

The common used Bis-GMA is a very rigid cross linker which is characterized by low shrinkage behaviour. But Bis-GMA has a very high viscosity which could not be handled[5]. Its consistency is comparable with viscous honey.

Therefore, Bis-GMA is need to be combined always by very short cross linkers like TEGDMA which have a diluent effect and reduce the viscosity of the matrix to allow proper handling of the material. But increasing the TEGDMA-fraction and lowering the Bis-GMA part leads to higher shrinkage and shrinkage stress of the composite[6]. However, the excellent shrinkage properties of Bis-GMA are annihilated to achieve good handling properties.

The only way the researchers at Heraeus Dental have seen to overcome the shrinkage issue was to develop a complete new cross linker technology. The TCD-urethane cross linker was identified as the perfect solution in this challenge. TCD is the abbreviation of Tricyclodecane which is the rigid core structure of the new crosslinker.

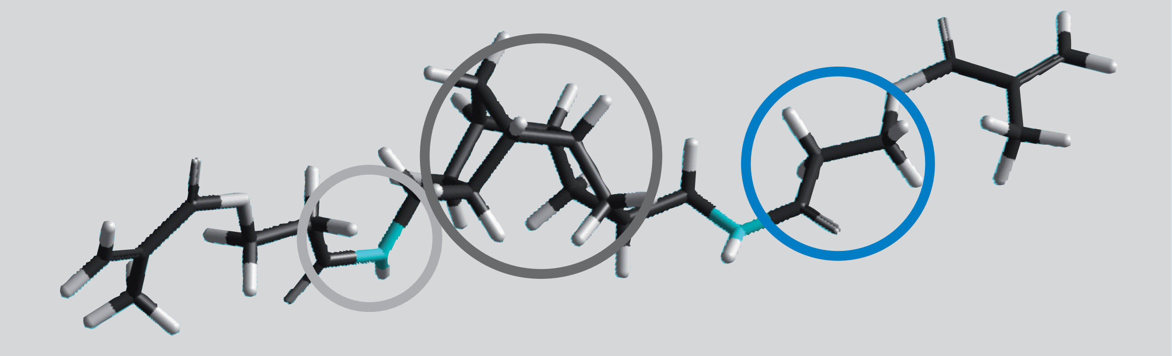
The advantages of the special structure is depict in the illustration below.

[5] Santerre JP, Shajii L, Leung BW: Relation of dental composite formulations to their degradation and the release of hydrolyzed polymeric-resin-derived products. Crit Rev Oral Biol Med 12 (2), 2001: 136-51

[6] Gonçalves F, Pfeifer C S, Ferracane J L, Braga R R: Contraction stress determinants in dimethacrylate composites. J Dent Res 87: 367–371 (2008)

TCD – rigid core structure – prevention of vibration movement to achieve a higher packing density of molecules for *low shrinkage* behaviour

Side Chains – optimized size for improved elasticity and reduced contraction stress for *reduced marginal gap formation*



Urethane Structure – generation of improved crosslinker reactivity for higher double bond conversion causing *increased mechanical performance and improved biocompatibility*

TCD-DI-HEA – the improved dental crosslinker exclusive from Heraeus Kulzer

The TCD- cross linker possesses equally to Bis-GMA a rigid backbone which reduces the packing density of the monomers in the uncured state.

Due to the Brownian motion all monomers are moving. Larger monomers show heavy vibrations which leads to increased distance of the monomers. The stiff core of the TCD-monomer we introduce with Venus Diamond reduces this vibration and the monomers can minimise the distance between themselves. The reduction of the distance is favourable when the cross linkers start with the radical polymerisation reaction. The resulting shrinkage of the polymer matrix which is determined by the changed distances during the curing process is therefore lower.

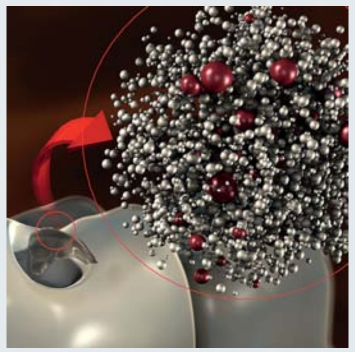
Urethan acrylates are well known as very reactive cross-linkers for radical polymerisation. This applies also to the TCD-monomer. The consequence is a higher degree of conversion compared with conventional Bis-GMA-based composites. That means a higher double bond conversion in the material is achieved which induces outstanding mechanical strength.

Further advantages of the TCD cross linker are the side chains of the monomer which are responsible for the elasticity of the resulting polymer network. This explains the excellent mechanical properties like flexural strength of Venus Diamond. Because of this elastic behaviour shrinkage stress during light curing is reduced as the elasticity of the side chains has the ability to compensate shrinkage stress to a certain degree. This may lead to perfect restoration margins.

For further optimisation of the cross linking matrix of Venus Diamond contains a special dendritic urethane-cross linker. This cross linker has binding areas in all planes which advances the formation of a 3D-network which also contributes to a paramount mechanical resistance towards mastication load. The high molecular weight improves additional the low shrinkage properties of Venus Diamond.

The Diamond Filler System
Apart from the matrix also the filler system of Venus Diamond was re-engineered basically.

Venus Diamond is a modern highly filled nano-hybrid composite and possesses a very high filler packing density. The filler ratio is 80–82 % by mass and 63.5–65.1% by weight. The filler size ranges between 5nm and 20µm. The filler are made from Barium-Aluminium-Fluoride glass which facilitates the good optical properties but also the superior radiopacity.



High packaging density of Venus Diamond

The advantages of this very dense filler system are reduced shrinkage, excellent mechanical stability and a long-lasting polishing result.

The added nano particles are discrete species created by a sol-gel-process which means that they are not agglomerated which leads to higher translucency and an outstanding colour adaptation potential.

The refraction index of the fillers and matrix are perfectly aligned to achieve additionally masked margins.

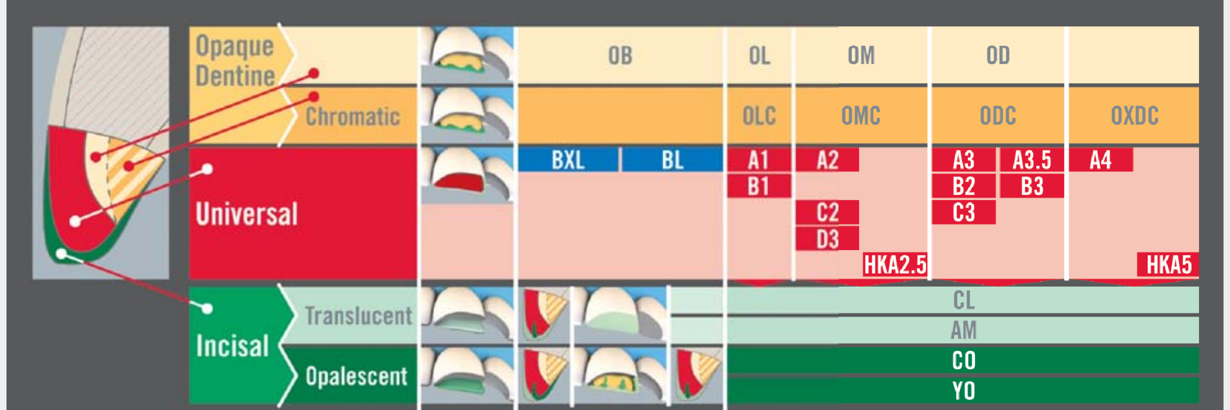
In thin layers the restoration absorbs the shade of the surrounding tooth structure which results in invisible restoration margins. However, with increased layer thickness chroma and translucency is elevated which yield to a high aesthetic performance which is demanded for example in class IV restorations.

The Diamond Comfort
Further adaptations of the initiator system, stabilizers and modifiers improved the handling properties of Venus Diamond.

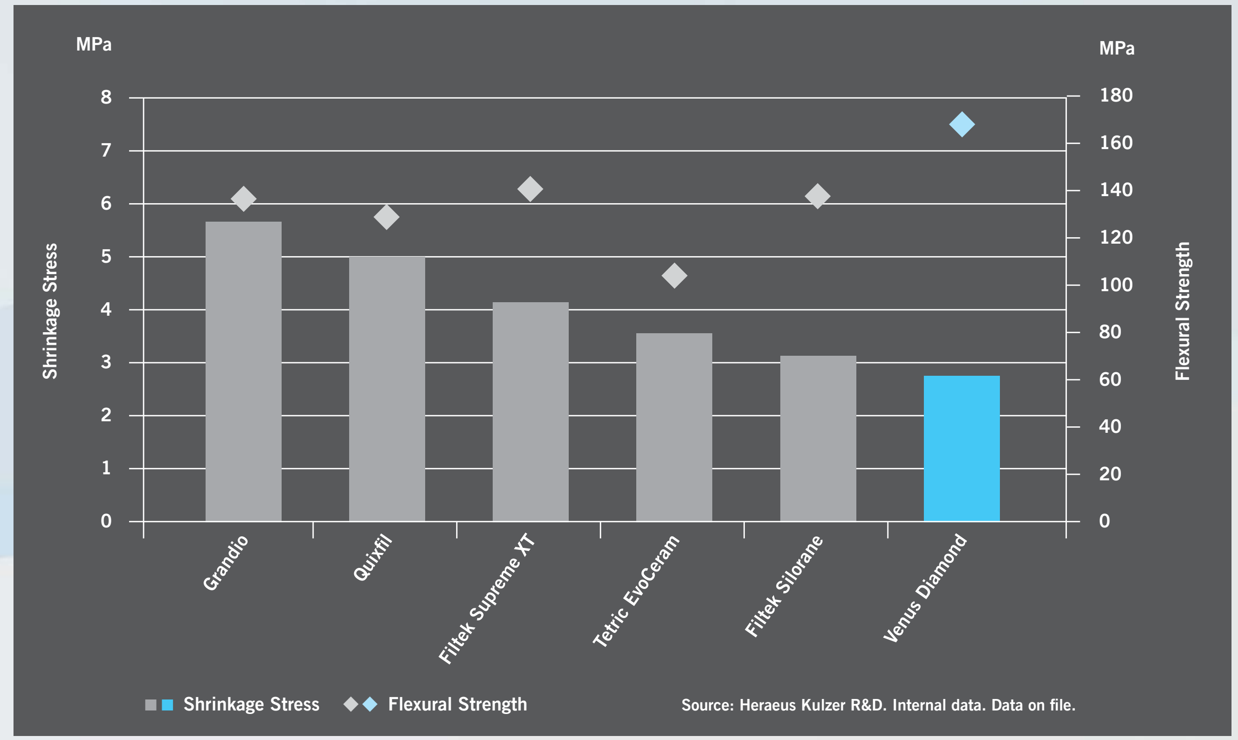
To permit easy and comfortable use for the dentist the working time is extended and the material shows superb handling characteristics. Venus Diamond does not stick to the instrument and is sculptable for precise reconstructions of functional surfaces.

The Diamond Effect
A new shade concept with 27 opaque dentine shades, universal shades and incisal shades are available in a wide range. Together with the unique superior colour adaptation this allows perfect restorations for high aesthetic demands: Multiple-shade restorations in complex cases and single-shade restorations for less complex cases can be performed easily.

3 Levels of translucency guide



The Diamond Class
The combination of different particle sizes, optimum filler density and content leads to high wear resistance. Venus Diamond offers a unique combination of minimal shrinkage stress as well as high flexural strength and durability.



Excellent strength, low shrinkage stress of Venus Diamond

The new flowable nano-hybrid composite Venus Diamond Flow is the perfect complement for Venus Diamond. It perfectly fits to the shade system of Venus Diamond and follows also the Heraeus philosophy of using new matrix systems for a improvement of the material properties.

Therefore, Venus Diamond Flow can be used to create aesthetically perfect, durable restorations.

It possesses optimal handling properties and produces an excellent match to the shade of the adjacent tooth structure due to its innovative diamond formula.

Indications

An increasing number of dentists prefer flowable composites for very easy placement of minimally invasive restorations. Venus Diamond Flow has exceptionally good handling properties with easy customisation of the shade – making it ideal for various indications:

- Enlarged fissure sealing
- Cavity lining – as the first layer for Class I and II cavities
- Class V fillings
- Minimally invasive Class I and II fillings in areas not subjected to masticatory forces
- Minimally invasive Class III fillings
- Small repairs of direct and indirect restorations combined with a suitable bonding agent
- Splinting of mobile teeth

Chemical Background and Advantages

The Diamond Formula

Venus Diamond Flow is also based on a new low shrinkage stress matrix system: UDMA and EBADMA are used as cross linkers.

The Diamond Filler System

The filler system is improved in the same way like Venus Diamond with a broad filler range between 20nm and 5µm. As fillers Barium-Aluminium-Fluoride-Silicate glass, Ytterbium-Fluoride and Silicium Oxide are used. The filler content is 65 % by mass or 41 % by volume.

The fillers produce an outstanding radiopacity and also paramount optical properties.

The Diamond Comfort

The newly developed nano-hybrid system provides optimal flow properties that facilitate the practice routine.

Venus Diamond Flow creates a uniform, smooth surface in areas of the cavity that are difficult to access. This is the perfect completion for the higher viscosity composite.

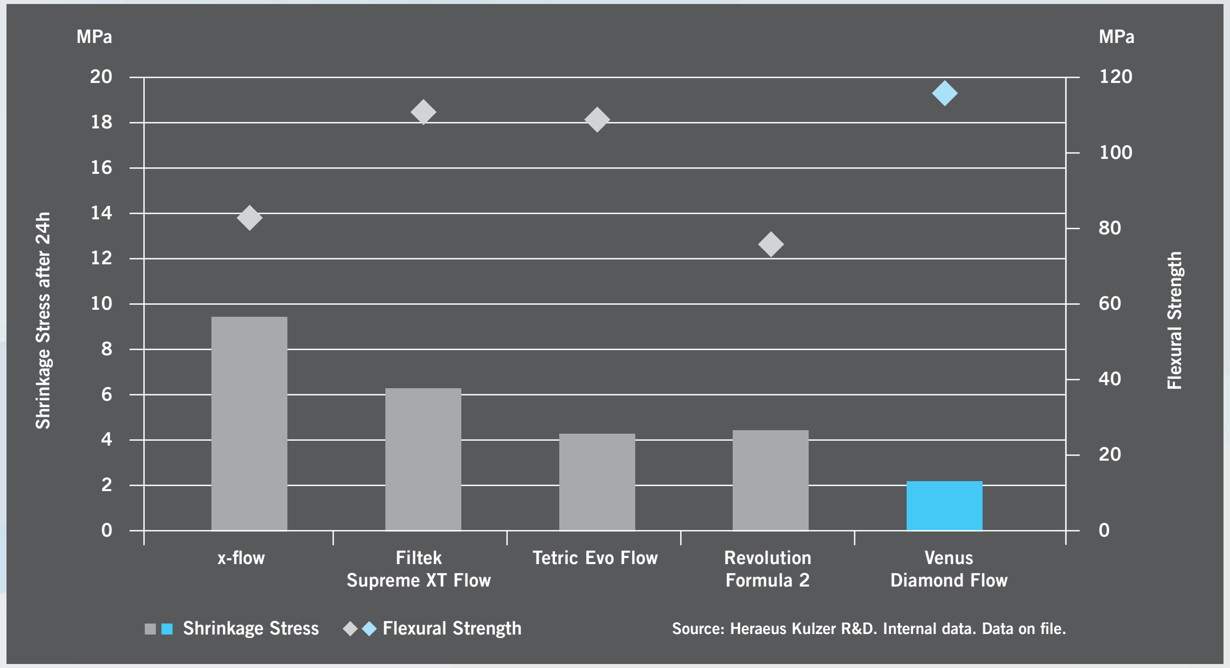
Venus Diamond Flow retains its shape and position following application. It flows only when pressure is applied with an instrument due to its thixotropic characteristics, which ensures that it does not flow out of the cavity before light curing. This is a particular advantage with Class V restorations.

The Diamond Effect

Venus Diamond Flow perfectly matches the shade of the adjacent tooth structure, which produces a highly aesthetic appearance and makes the restoration virtually indistinguishable from the natural tooth. An attractive shine is easily and quickly attained due to its excellent polishing properties. This is a characteristic that impresses both dentists and patients.

The Diamond Class

Venus Diamond Flow possesses a unique combination of high flexural strength and low shrinkage stress. This makes the restoration more resistant and more durable.



Excellent strength and low shrinkage stress of Venus Diamond Flow

Mechanical properties
Venus Diamond and Venus Diamond Flow

Mechanical properties of Venus Diamond and Venus Diamond Flow at a glance

Mechanical properties	Venus Diamond	Venus Diamond Flow
Flexural strength [MPa]	169	117
Modulus of elasticity [GPa]	12.6	4.8
Compressive strength [MPa]	391	332
Hardness	578	216
Hardness under 2 mm	521	226
Sensitivity to ambient light @ 8kLux [s]	210	100
Shrinkage [%-vol] Watts method	1.5	3.4
Shrinkage force [MPa] after 1 h of water storage	2.8	2.02
Shrinkage force [MPa] after 24 h of water storage	4.0	2.3
Reflection [%] after brush abrasion (100.000 cycles)	7.0	7.1
Abrasion depth [µm] after ACTA method (300.000 cycles)	19	33.3
Wear resistance depth [µm] after mastication simulation (1.5 Mio cycles)	120.9	159.2
Radiopacity [%-Al]	325	295

Source: Internal tests by Heraeus Kulzer R&D. Data on file

Clinically proven worldwide
Study overview

Numerous studies have been performed on Venus Diamond and Venus Diamond Flow by leading independent scientific institutes all over the world.

The following chapters describe investigations performed to characterise Venus Diamond in further details and in comparison to other currently used restoratives.

External Testing of Venus Diamond and Venus Diamond Flow by 20 Study Groups worldwide

North America

Dr. Yaman
University of Michigan
Ann Arbor[2]

Dr. Pimenta
University of North Carolina
at Chapel Hill, et al.[1]

Prof. Paravina
University of Texas,
Dental Branch at Houston[1]

Dr. Vargas
University of Iowa[1]

Prof. Munoz
State University of New York
at Buffalo[1]

Dr. Christensen
TRAC Research Foundation
Provo, Utah[1]

South America

Prof. Braga
University of Sao Paulo
Brazil[1]

Asia

Dr. Kurokawa
Niigata University
Japan[1]

Dr. Kanehira
Tohoku University
Sendai
Japan[1]

Dr. Takahashi
Tokyo Medical and
Dental University
Japan[1]

Dr. Suzuki
Showa University
Tokyo
Japan[1]

Dr. Endo
Tohoku University
Sendai
Japan[1]

Europe

Dr. Kleverlaan,
Prof. Feilzer
Academic Center
for Dentistry
Amsterdam
The Netherlands[1]

Prof. Breschi,
Prof. Cadenaro
University of Trieste
Italy[1,2]

Prof. Cerutti
University of Brescia
Italy[1,2]

Dr. Heintze,
Prof. Roulet
Ivoclar Vivadent AG,
Schaan
Liechtenstein[1]

Europe

Prof. Finger
University of Cologne
Germany[1]

Dr. Schattenberg,
Prof. Ernst
University of Mainz
Germany[1]

Dr. Koplin
Fraunhofer Institut of
Mechanics and Materials
Freiburg
Germany[1]

Dr. Ilie
Ludwig-Maximilians-
University
Munich
Germany[2]

Prof. Hickel, Prof. Manhart
Ludwig-Maximillians-
University
Munich
Germany[1]

[1] = Venus Diamond
[2] = Venus Diamond Flow

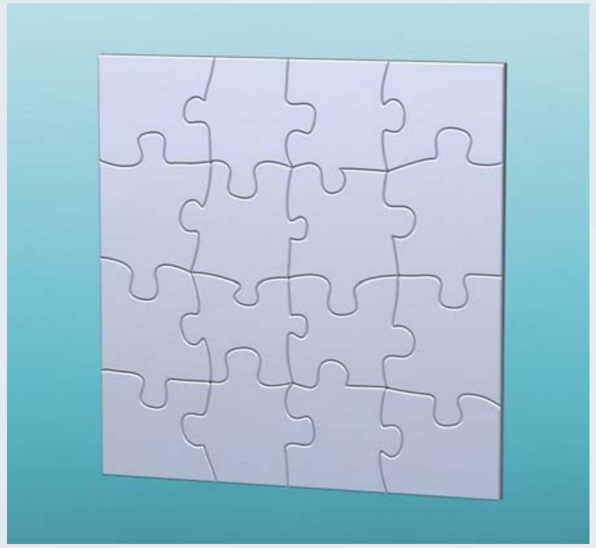
In vitro studies
Mechanical properties

Mechanical properties
Shrinkage and shrinkage stress

Mechanical properties such as shrinkage, shrinkage stress, flexural strength, rigidity, hardness, abrasion stability and degree of conversion are important parameters that determine durability of fillings, particularly in stress-bearing areas. Measurements conducted in in-vitro-studies provide preliminary information on clinical longevity of composite fillings.

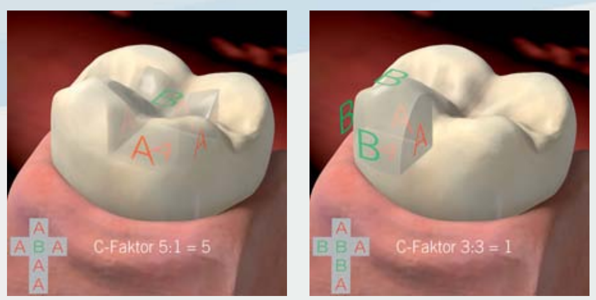
The process of polymerisation provokes a certain percentage of volume shrinkage of resin materials during shrinkage. The reason for this behaviour is that crosslinkers have a certain distance from each other before curing. During the curing process the monomers have to overcome this distance to crosslink.

Space between crosslinkers prior polymerisation



After polymerisation is the distance between crosslinkers closed

Dental resins cannot shrink freely as they are bonded with an adhesive system to the tooth surface. Due to the geometry of the cavity the composite filling is bonded mostly to more than one wall. This is described with the c-factor of a cavity[7]. The more tooth walls are involved in the cavity the higher is the c-factor.



C-factor is determined by cavity geometry

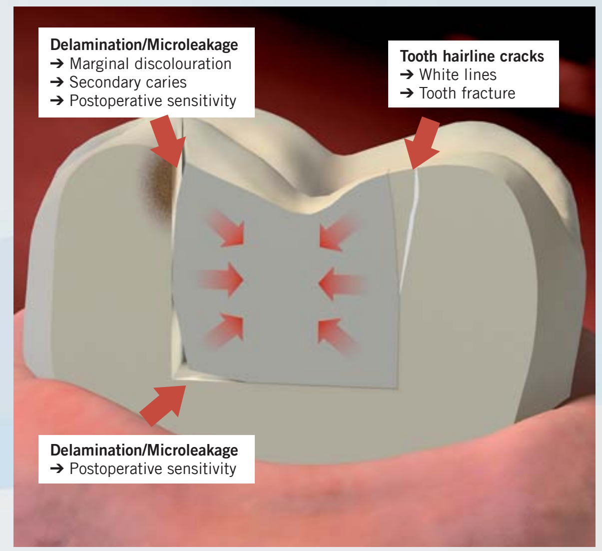
Because of the bonding to the cavity walls and the shrinking of the resin, a certain stress develops in the system tooth, adhesive layer and composite during polymerisation[8]. This stress is also influenced by the cavity geometry, cavity extent and the application like curing and filling method[9]. Stress is determined as the force per unit area.

[7] Feilzer AJ, De Gee AJ and Davidson CL: Setting Stress in Composite Resin in Relation to Configuration of the Restoration. J Dent Res, 1987 66: 1636-9

[8] Braga RR, Ferracane JL: Contraction stress related to degree of conversion and reaction kinetics. Dent Res. 2002 Feb;81(2):114-8.

[9] Kurokawa R, Finger WJ, Hoffmann M, Endo T, Kanehira M, Komatsu M, Manabe A. Interactions of self-etch adhesives with resin composites. J Dent 2007; 35: 923-9.

This stress is also described as shrinkage stress or contraction stress. High stress values can lead to failure of bond formation with the surrounding tooth structure[10,11]. Further, high stress levels can increase marginal gaps and staining, postoperative sensitivity and the development of secondary caries. Also the integrity of the remaining tooth structure can be affected by high stress values which lead to hairline cracks and fractures[12,13].



Set of problems related to high shrinkage stress

Several variables like the elasticity of a composite resin/adhesive, the rheology during curing, the light curing or the type of monomer influences the development of this stress.

This explains why not only should been paid attention to low shrinkage characteristics of a dental composite. More important are factors which are helping to reduce shrinkage stress[14].

So, a low degree of volume loss and shrinkage stress helps improving marginal adaptation, thus minimizing the risk of a "loss of retention, secondary caries, marginal staining and deterioration, and hypersensitivity."[15] And this, in turn, contributes to the longevity of composite fillings.

Venus Diamond and Venus Diamond Flow induce very low polymerisation stress levels due to their special developed crosslinker matrix.

[10] Koplin C, Jaeger R, Hahn P: Kinetic model for the coupled volumetric and thermal behavior of dental composites. Dent Mater. 2008 Aug; 24(8):1017-24.

[11] J.R. Condon, J.L. Ferracane, 1998: Reduction of composite contraction stress through non-bonded microfiller particles, Dental Materials 14; 256-260.

[12] Bausch JR, de Lange K, Davidson CL, Peters A, de Gee AJ: Clinical significance of polymerization shrinkage of composite resins. J Prosthet Dent. 1982;48(1):59-67.

[13] Tandbirojn D, Versluis A, Pintado MR, DeLong R, Douglas WH: Tooth deformation patterns in molars after composite restoration. Dent Mater 20 (6), 2004:535-542.

[14] Tandbirojn D, Pfeifer CS, Braga RR, Versluis A: Do Low-shrink Composites Reduce Polymerization Shrinkage Effects? JDR, 2011, 90 (5): 596-601.

[15] Kurokawa R, Finger WJ, Hoffmann M, Endo T, Kanehira M, Komatsu M, Manabe A. Interactions of self-etch adhesives with resin composites. J Dent 2007; 35: 923-9.

Setting Shrinkage Stress of Venus Diamond. Setting shrinkage of Venus Diamond determined in the ACTA dilatometer

Source

Kleverlaan CJ, Feilzer AJ, Academic Center for Dentistry Amsterdam (ACTA), unpublished test report. Data on file. 2008

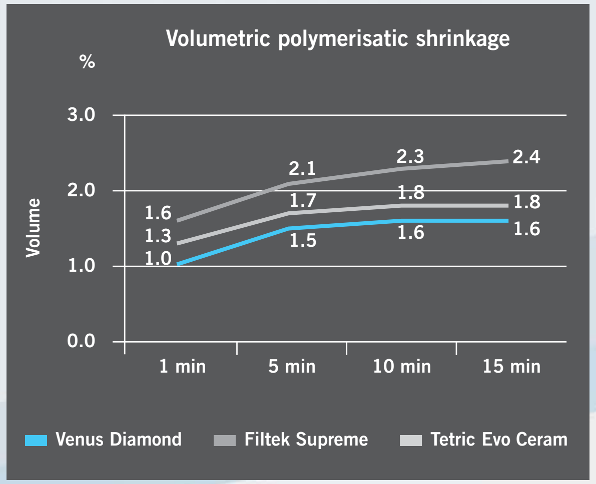
Objective

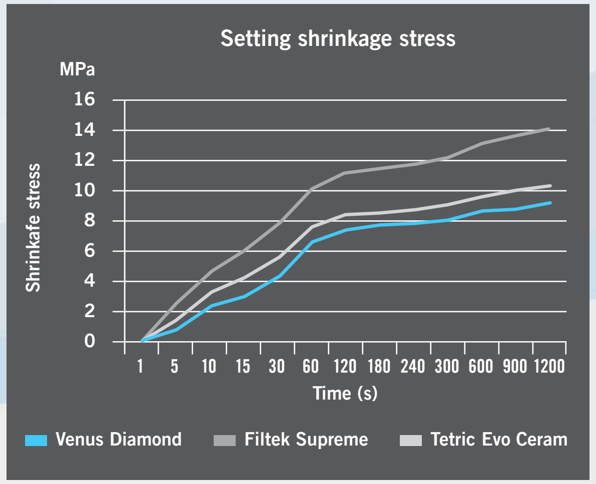
This study had the aim to measure setting shrinkage stress and volumetric shrinkage during polymerisation. Three materials have been tested: Venus Diamond (Heraeus Kulzer), Tetric Evo Ceram (Ivoclar Vivadent) and Filtek Supreme XT/Plus (3M ESPE).

Materials and Methods

Shrinkage stress was determined using a tensilometer during the first 30 min. The measurement for polymerisation shrinkage was carried out with the ACTA dilatometer during the first 30 min after light curing.

Results





Venus Diamond possesses excellent low shrinkage and low shrinkage stress behaviour

Conclusion

Venus Diamond exhibits lowest shrinkage stress and volumetric shrinkage in this test.

Venus® Diamond – In vitro studies
Shrinkage and shrinkage stress

Interactions of self-etch adhesives with resin composites

Source

Kurokawa R, Finger WJ, Hoffmann M, Endo T, Kanehira M, Komatsu M, Manabe A., Niigata University, Japan
J Dent 2007; 35: 923-9

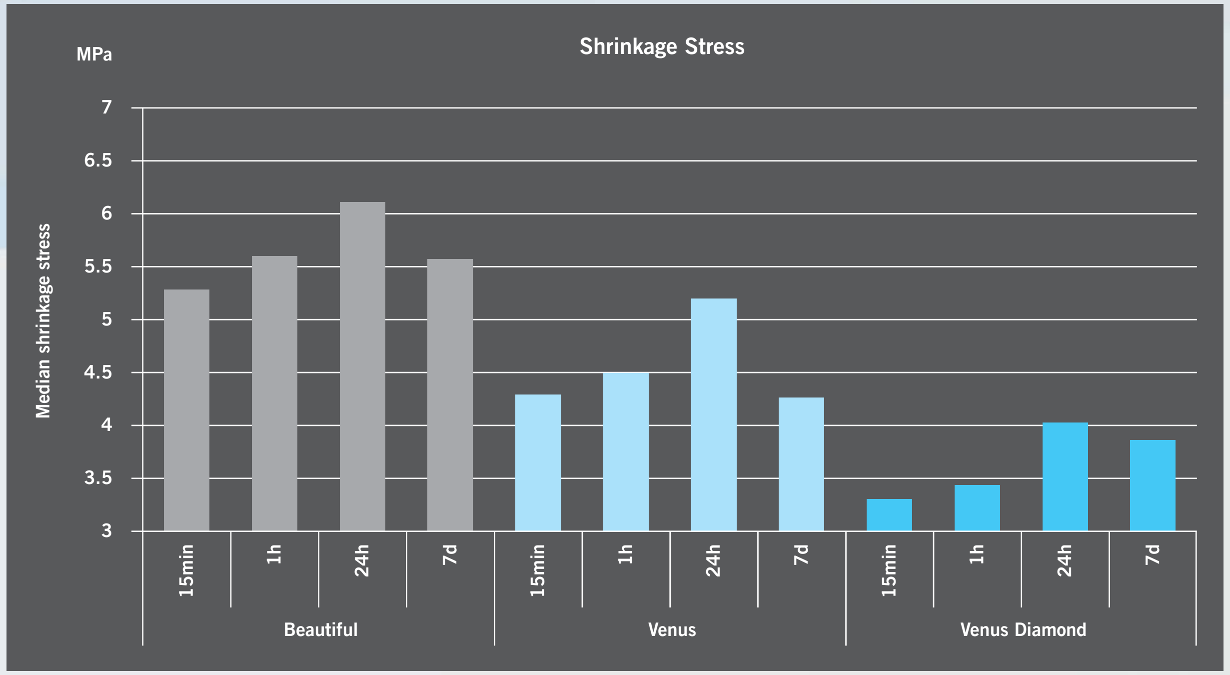
Objective

In the context of a study with the objective of exploring interactions of self-etch adhesives with resin composite, shrinkage and polymerisation contraction stress was measured on three resin composites: Venus Diamond, Venus (both Heraeus Kulzer) and Beautifil (Shofu).

Materials and Methods

The mean percentage of volume shrinkage during polymerisation was evaluated using the bonded-disk method according to Watts and Cash. Polymerisation shrinkage stress was investigated using photoelastic measurements: Composite was filled in cylindrical holes with a diameter and depth of 4 mm in Araldit B epoxide plates. After curing the composite the localization and diameter of the first order isochromatic ring was determined after 15 min, 1h, 24h and 1 week. Shrinkage stress calculations were done on that base.

Results



Best shrinkage stress values for Venus Diamond

Beautifil exhibited 2.58 %, Venus 2.74 % and Venus Diamond 1.53 % volume shrinkage after 5 min. Venus Diamond showed the lowest volumetric shrinkage and the lowest shrinkage stress values amongst the tested composites.

Conclusion

There is no correlation between bond strength and marginal adaption. But reduced shrinkage and low shrinkage stress are important determinants of marginal adaptation.

Venus® Diamond – In vitro studies
Shrinkage and shrinkage stress

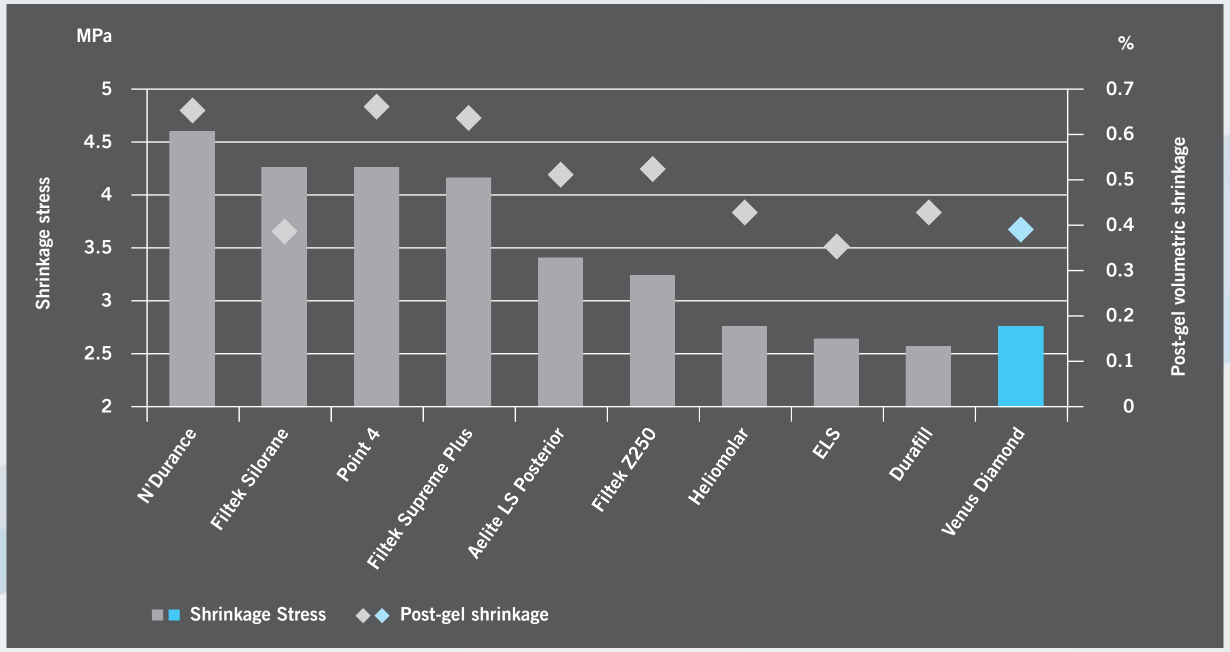
Polymerisation stress, shrinkage and elastic modulus of current low-shrinkage restorative composites

Source
Boaro LCC, Gonçalves F, Guimarães TC, Ferracane JL, Versluis, Braga RR
University of Saõ Paulo, Brazil
Dental Materials 26, 2010: 1144-50

Objective
Comparison of low shrinkage composites in terms of shrinkage stress, shrinkage and flexural modulus.

Materials and Methods
10 different composites with different matrix chemistry were evaluated: Venus Diamond, Durafill (both Heraeus Kulzer), Filtek Z250, Filtek Supreme Plus, Filtek Silorane (all three 3M ESPE), Heliomolar (Ivoclar Vivadent), Aelite LS Posterior (Bisco), Point 4 (Kerr), ELS (Saremco) and N'Durance (Septodont). Shrinkage Stress was evaluated using a universal testing machine, shrinkage was tested by a mercury dilatometer. Post-gel shrinkage was measured by strain-gages and elastic modulus was determined by a 3-point bending test.

Results



Low post-gel shrinkage leads to reduced shrinkage stress in Venus Diamond

Shrinkage stress correlated with post-gel shrinkage (except for Filtek Silorane which showed high stress). Venus Diamond exhibited a total volumetric low shrinkage of 1.8 [%] and an flexural modulus of 4.5 GPa. Venus Diamond revealed reduced shrinkage and shrinkage stress results in this test. especially its post-gel shrinkage is very low.

Conclusion
Not all low-shrinkage composites in this test demonstrate low polymerisation shrinkage values.

Venus® Diamond – In vitro studies
Shrinkage and shrinkage stress

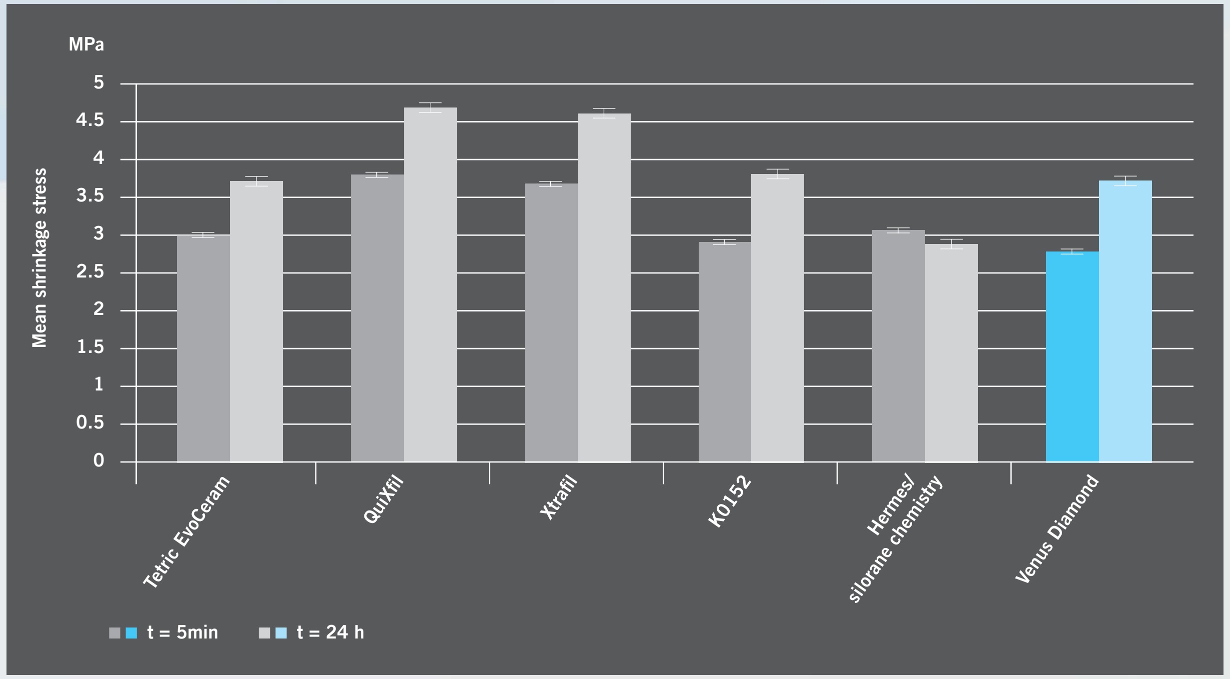
Shrinkage stress of new experimental low shrinkage resin composites

Source
Schattenberg A, Meyer GR, Gräber H, Willershausen B, Röhrig B, Ernst C-P
University of Mainz, Germany
Deutsche Zahnärztliche Zeitschrift 62, 2007: 518-24

Objective
Objective of this study was to examine the polymerisation contractions stress of experimental low shrinkage resin composites (KO 152/Dentsply, Venus Diamond/Heraeus Kulzer, Hermes/3M ESPE) as compared to new but established products (Tetric EvoCeram/Ivoclar Vivadent, QuiXfil/Dentsply, Xtrafil/Voco).

Materials and Methods
Cylindrical cavities in Araldit B epoxide resin plates (diameter: 5 mm) were filled with the different composite materials and then cured with a QTH curing device for 60 s. Polymerisation shrinkage stress (in MPa) were calculated based on the diameter and localisation of the first order of isochromatic curves 5 min and 24 h after curing.

Results



Excellent shrinkage stress values for Venus Diamond

Conclusion
New low shrinkage composites demonstrate significantly reduced shrinkage stress.

Venus® Diamond flow – In vitro studies

Shrinkage and shrinkage stress

Contraction Stress and Extent of Polymerization of Flowable Composites

Source

Codan B, Navarra CO, Marchesi G, De Stefano Dorigo E, Breschi L, Cadenaro M
University of Trieste, Italy
J Dent Res 89 (Spec Iss B): 3057, 2010 (www.dentalresearch.com)

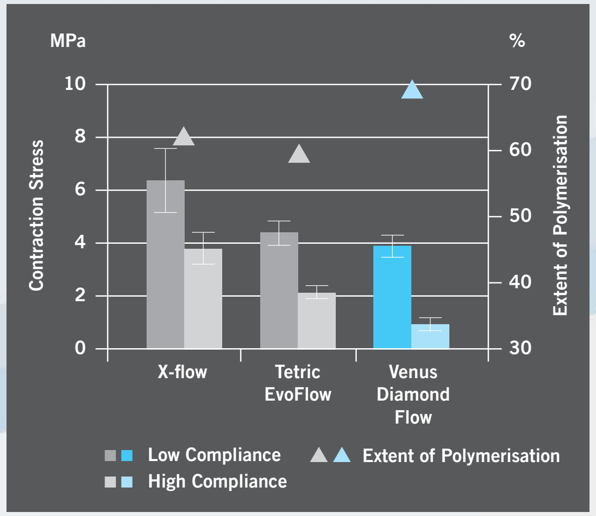
Objective

Purpose of the research project was to measure the polymerisation stress and extent of polymerisation of different flowable composites: Venus Diamond Flow (Heraeus Kulzer), X-flow (Dentsply), Filtek Supreme XT/Plus Flow (3M ESPE), Tetric Evo Flow (Ivoclar Vivadent), Revolution-Formula 2 (Kerr).

Materials and Methods

Shrinkage stress during polymerisation was assessed using a high-compliance and a low-compliance stress-strain analyzer. For the high compliance measurement the setups with the different composites were connected to a load-sensor. The contraction force (N) generated during polymerisation was continuously recorded for 300 s after photo-initiation. The low-compliance system consisted of two stainless steel cylinders as bonding substrates which were attached to an extensometer. This time the force (N) necessary to keep specimen height constant was recorded by the load cell for 300 s after photo-initiation. Micro-Raman spectography was used to calculate the extent of polymerisation of the tested materials.

Results



Venus Diamond Flow demonstrates lowest shrinkage stress

Venus Diamond Flow showed significantly the lowest shrinkage stress and highest extent of polymerisation in this investigation.

Conclusion

Venus Diamond exhibits a low shrinkage stress potential in both testing setups.

Venus® Diamond – In vitro studies

Shrinkage and shrinkage stress

Contraction stress of low-shrinkage composite materials assessed with different testing systems.

Source

Marchesi G, Breschi L, Antoniolli F, DiLenarda R, Ferracane J, Cadenaro M
University of Trieste, Italy
Dental Materials 26, 2010: 947-53

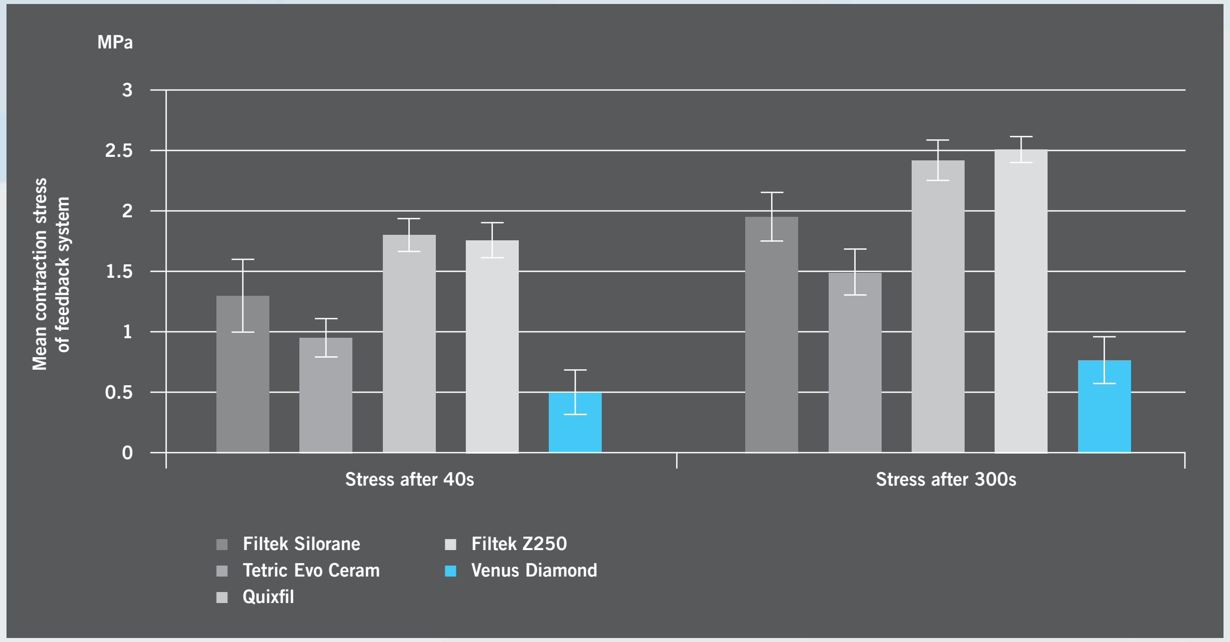
Objective

The contraction stress of a silorane-based material and a new low-shrinkage nanohybrid composite were compared to three conventional dimethacrylate-based resin composites using two different measuring systems.

Materials and Methods

The evaluated materials were Filtek Silorane LS (3M ESPE), Venus Diamond (Heraeus Kulzer), Tetric EvoCeram (Ivoclar Vivadent), Quixfil (Dentsply), and Filtek Z250 (3M ESPE). Shrinkage stress during polymerisation was assessed using a high-compliance and a low-compliance stress-strain analyzer. For the high compliance measurement the setups with the different composites were connected to a load-sensor. The contraction force (N) generated during polymerisation was continuously recorded for 300 s after photo-initiation. The low-compliance system consisted of two stainless steel cylinders as bonding substrates which were attached to an extensometer. This time the force (N) necessary to keep specimen height constant was recorded by the load cell for 300 s after photo-initiation.

Results



Study confirms lowest stress rates for Venus Diamond

Venus Diamond depicts in both test setups the lowest shrinkage stress values. In the feedback system those values were significantly lower than the competitor values.

Conclusion

Venus Diamond exhibits the lowest shrinkage stress values in both testing setups. Contraction stress is higher when measured in a test system with a feedback. This study confirms that reducing the shrinkage does not ensure reduced shrinkage stress.

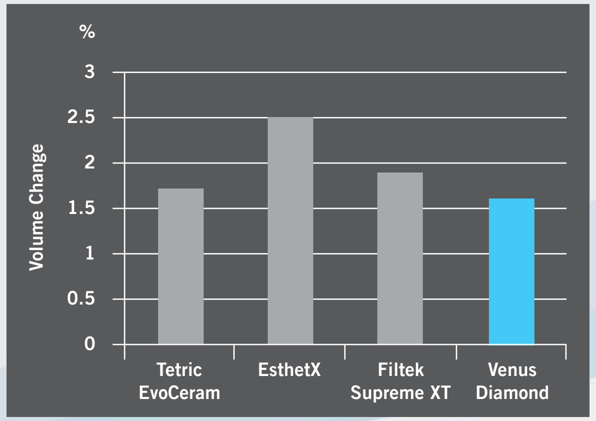
Venus® Diamond – In vitro studies
Shrinkage and shrinkage stress

Comparative investigation of an experimental composite and three other composites

Source
Koplin C, da Silva Rodrigues G, Jaeger R
Fraunhofer Institut of Mechanics of Materials, Freiburg, Germany, 2008.
Data on file

Objective
Purpose of this study was to evaluate volume shrinkage during polymerisation. Measurements were conducted on the following composite filling materials: Venus Diamond (Heraeus Kulzer), Tetric EvoCeram (Vivadent Ivoclar), Filtek Supreme XT/Plus (3M ESPE) and EsthetX (Dentsply).

Results



Venus Diamond features the lowest volumetric shrinkage

Conclusion
In this test Venus Diamond has a shrinkage of 1.62 % and therefore the lowest within this group of tested composites.

Materials and Methods
The volumetric behavior during and after the curing of four dental composites was measured by the "Archimedes' principle". With the initiation of the curing process, five buoyancy weighing measurements were taken.

Mechanical Stability

Flexural strength reflects which bending force a material endures before fracture. Composite materials for posterior restorations need to resist at least a flexural strength of 80 MPa according to ISO 4049. Especially in thin layers or overhanging areas high flexural strength values are important to avoid fracture of the restoration. Venus Diamond exhibts highest flexural strength values to resist the mastication forces.

Flexural strength of flowable composites is lower due to a decreased filler load. Nevertheless, Venus Diamond Flow reveals also a high flexural strength compared with other flow composites.

The value of the flexural modulus or modulus of elasticity is increased the more the material resists to its deformation under load. Materials with high flexural modulus are rigid whereas materials with a low flexural modulus are elastic. This flexural modulus needs to be good balanced as composites should not be too rigid or elastic. According its indication the flexural modulus of a resin composite is adjusted. Universal composites need higher rigidity because of the direct applied mastication load. Contrary, flowable composites need to be more elastic to act as a stress breaker. Venus Diamond and Venus Diamond Flow have indication-optimised flexural moduli.

Elastic and ridgid examples

Diametral tensile strength also characterizes the fracture resistance of a material. The higher the diametral tensile strength values the higher is the resistance to breaks.

Compression strength is defined as the capacity of a material to resist pushing forces in axial direction. Dentine shows a compressive strength of approx. 300 MPa[16]. Therefore, a composite material should need at least a comparable or exceeding value to withstand the chewing forces.

Venus Diamond exhibts outstanding compression and diametral tensile strength figures to minimize the risk of restoration fractures during service.

Hardness is defined as ability to resist a localised compressive load without deforming plastically. During mastication restorations are exposed to various food particles like seeds which are very hard. These particles involve the risk of filling fractures. Therefore, it is advantageous to use a hard restoration material to reduce filling failures. The high cross-linked matrix together with the high filler load and dense filler packability causes the increased hardness of Venus Diamond which enables long-lasting reconstructions.

Diamond is the hardest mineral.

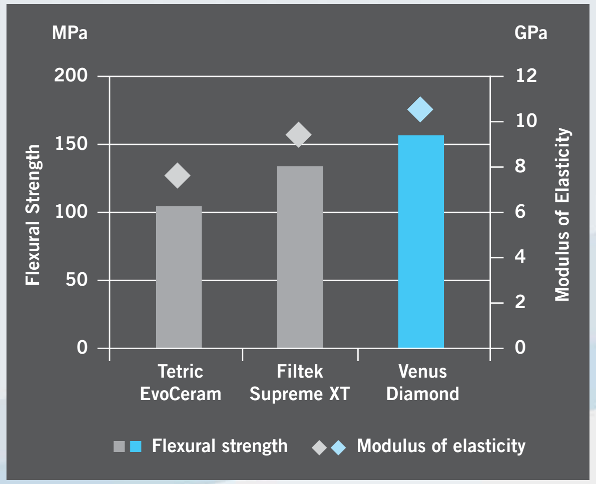
[16] Watts DC, El Mowafy OM, Grant AA: Temperature-dependence of Compressive Properties of Human Dentin. J Dent Res, 1987, 66: 29-32

Flexural Strength and E-module of Venus Diamond, Tetric EvoCeram and Filtek Supreme XT

Source
Kleverlaan CJ, Feilzer AJ
Academic Center for Dentistry Amsterdam (ACTA)
Test report 2008. Data on file

Objective
Aim of the Study was to compare the flexural strength and modulus of elasticity of Venus Diamond with Tetric EvoCeram (Ivoclar Vivadent) and Filtek Supreme XT (3M ESPE).

Results



Venus Diamond depicts topmost flexural strength

Conclusion
Venus Diamond demonstrates the highest flexural strength and flexural modulus values in this investigation.

Materials and Methods
A 3-point bending test according ISO Standard 4049 was performed to determine flexural strength and modulus of elasticity.

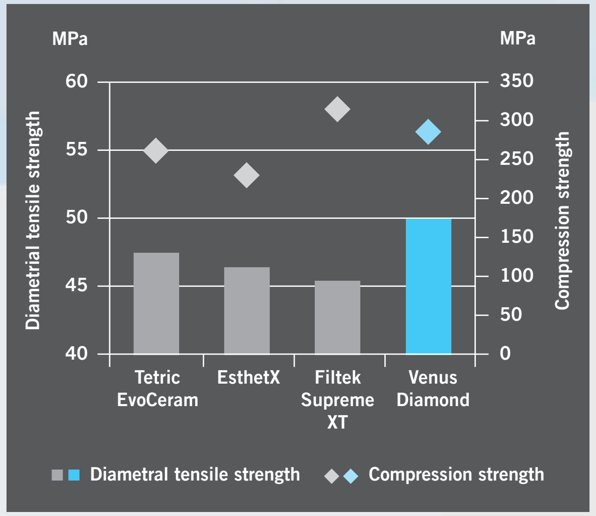
Venus® Diamond – In vitro studies
Mechanical stability

Calculating internal stress during curing of dental composites

Source
Koplin, da Silva Rodrigues G, Jaeger R
Fraunhofer Institut of Mechanics of Materials, Freiburg, Germany
J Dent Res 88 (Spec Iss B): 145, 2009 (www.dentalresearch.org)

Objective
Purpose of this study was to evaluate diametral tensile and compression strength of different universal composites. Measurements were conducted on the following composite filling materials: Venus Diamond (Heraeus Kulzer), Tetric EvoCeram (Vivadent Ivoclar), Filtek Supreme XT/Plus (3M ESPE) and EsthetX (Dentsply).

Results



Excellent mechanical features of Venus Diamond

Conclusion
Venus Diamond reveals the best diametral tensile and excellent compression strength to resist mastication forces in this test.

Materials and Methods
Compression strength was determined by application of a force on upright cylindrical composite specimen (4mm diameter, 8mm height) until fracture. Diametral tensile strength was measured by a force application on the edge of composite discs (6mm diameter, 3mm heigth) until breakage.

Venus® Diamond – In vitro studies
Mechanical stability

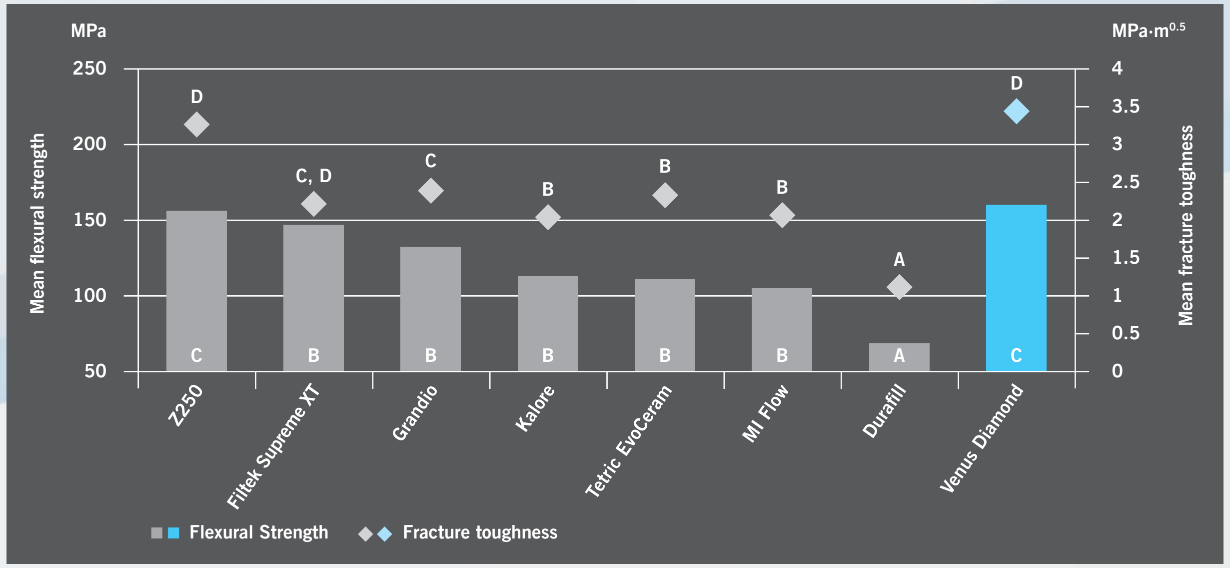
Comparative evaluation of mechanical characteristics of nanofiller containing resin composites

Source
Takahashi H, Finger WJ, Endo T, Kanehira M, Koottathape N, Balkenhol M, Komatsu M
Advanced Biomaterials, Department of Restorative Sciences, Division of Oral Health Sciences, Graduate School of Medical and Dental Sciences, Tokyo Medical and Dental University, Tokyo, Japan
American Journal of Dentistry, in press 2011

Objective
Purpose of this investigation was the determination of basic mechanical characteristics of six commercially available nano filler containing resin composites compared to a micro hybrid and a micro filled reference material. The tested hypothesis was that there are no differences in terms of the mechanical properties between the materials.

Materials and Methods
Durafill VS (Heraeus Kulzer) and Filtek Z250 (3M ESPE) were used as micro filled and micro hybrid references. The nano filler containing products were: Filtek Supreme XT (3M ESPE), Grandio (Voco), Kalore (GC), MI Flow (GC), Tetric EvoCeram (Ivoclar Vivadent), and Venus Diamond (Heraeus Kulzer). The following material characteristics were determined after 24 hours water storage of the specimens (n=6): Flexural strength, yield stress (0.02 %) and modulus, tensile strength, and modulus, diametral tensile strength, Knoop hardness, and fracture toughness.

Results



Venus Diamond shows supreme resistance to mastication load

No significant differences between specimens with same letters were found.

Venus Diamond achieved a tensile strength of 74.36 MPa, a yield stress of 78.48 MPa, flexural modulus of 10.924 GPa, tensile modulus of 10.539 GPa, diametral tensile strength of 58.82 MPa and a knoop hardness of 41.62 kgf/mm². Venus Diamond achieved excellent mechanical results. Particulary flexural strength and fracture toughness were superior compared with the other tested composites.

Conclusion
The nano filled Filtek Supreme XT and the nano hybrids Grandio and Venus Diamond show mechanical properties very similar to the micro hybrid Z250 and could thus be used for the same universal clinical indications, whereas MI Flow and the prepolymer loaded Kalore and Tetric EvoCeram should be used more restrictedly for restoration of posterior teeth.

Venus® Diamond flow – In vitro studies
Mechanical stability

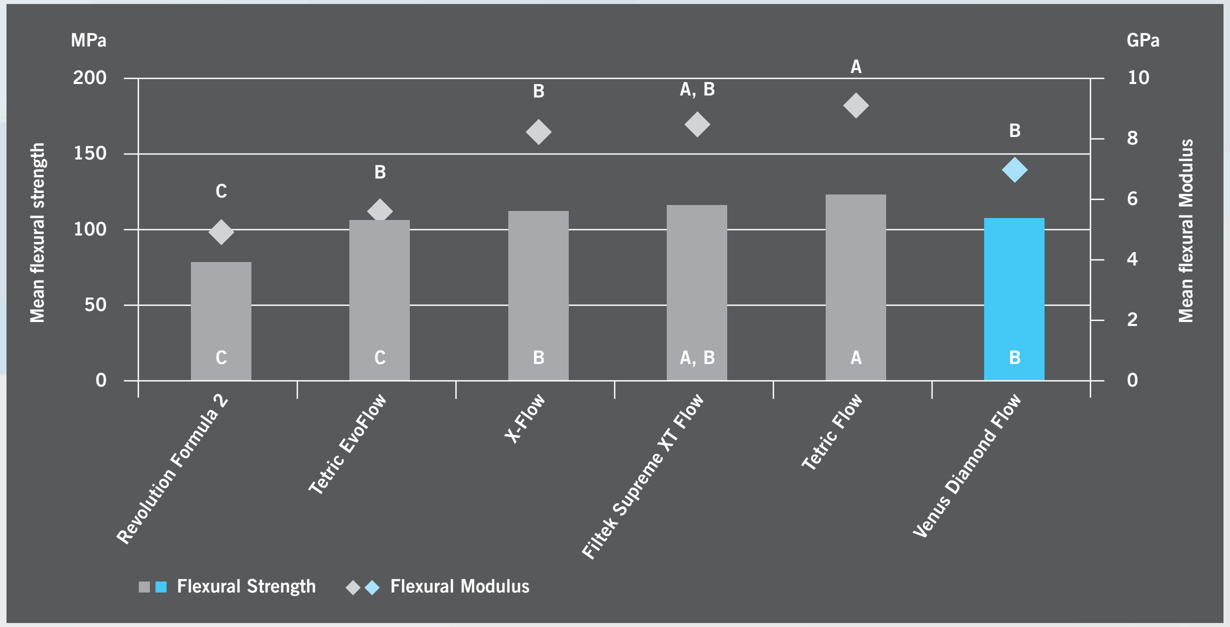
Study report: Bis-GMA free flowable nano-hybrid composite

Source
Ilie N, Ludwig-Maximilians-Universität, Munich, Germany 2009
Data on file

Objective
Aim of the study was to compare the flexural strength and the flexural modulus of six different flowable composites.

Materials and Methods
Flexural strength and flexural modulus were obtained by 3-point-bending test according to ISO guideline 4049. Tested materials were Venus Diamond Flow (Heraeus), Revolution Fomula 2 (Kerr), Tetric Evo Flow and Tetric Flow (both Ivoclar Vivadent), X-Flow (Dentsply) and Filtek Supreme XT Flow (3M ESPE).

Results



Venus Diamond Flow reveals an optimised flexural modulus

No significant differences between specimens with same letters were found.

Conclusion
Venus Diamond Flow exhibits in both tests good macro-mechanical properties compared with commercial available flowable composites.

Comparative investigation of an experimental composite and three other composites

Source

Koplin C, da Silva Rodrigues G, Jaeger R. Report 2008. Data on file.

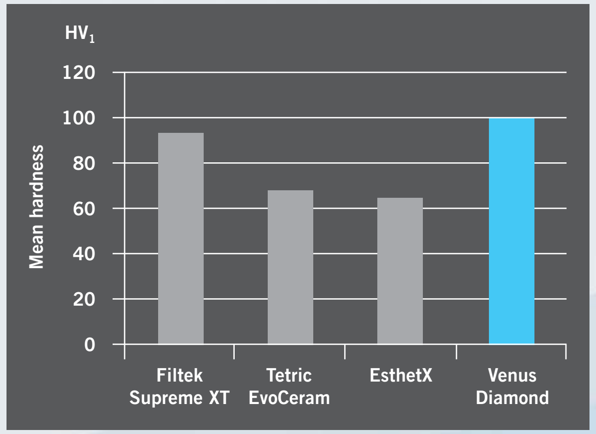
Objective

Testing the hardness of a composite allows conclusions about the wear resistance of the material in clinical use. This for, the hardness of Venus Diamond, Tetric EvoCeram, EsthetX and Filtek Supreme XT was measured.

Materials and Methods

For all composites 5 hexagonal samples (edge length 5.75 mm and thickness 2 mm) were manufactured with a Dentacolor XS Polymerization unit. The trials were performed with a Vickers hardness tester.

Results



Venus Diamond achieves the supreme hardness values

Conclusion

Venus Diamond has superior hardness in this test. Dental resins with high hardness values resist better sharp and hard food particles.

Venus® Diamond – In vitro studies
Mechanical stability

Marginal adaptation, microhardness of reduced-shrinkage composite cured with different lights

Source

Pimenta LA, et al.
University of North Carolina at Chapel Hill, USA
J Dent Res 86 (Spec Iss A): 0126, 2007 (www.dentalresearch.org)

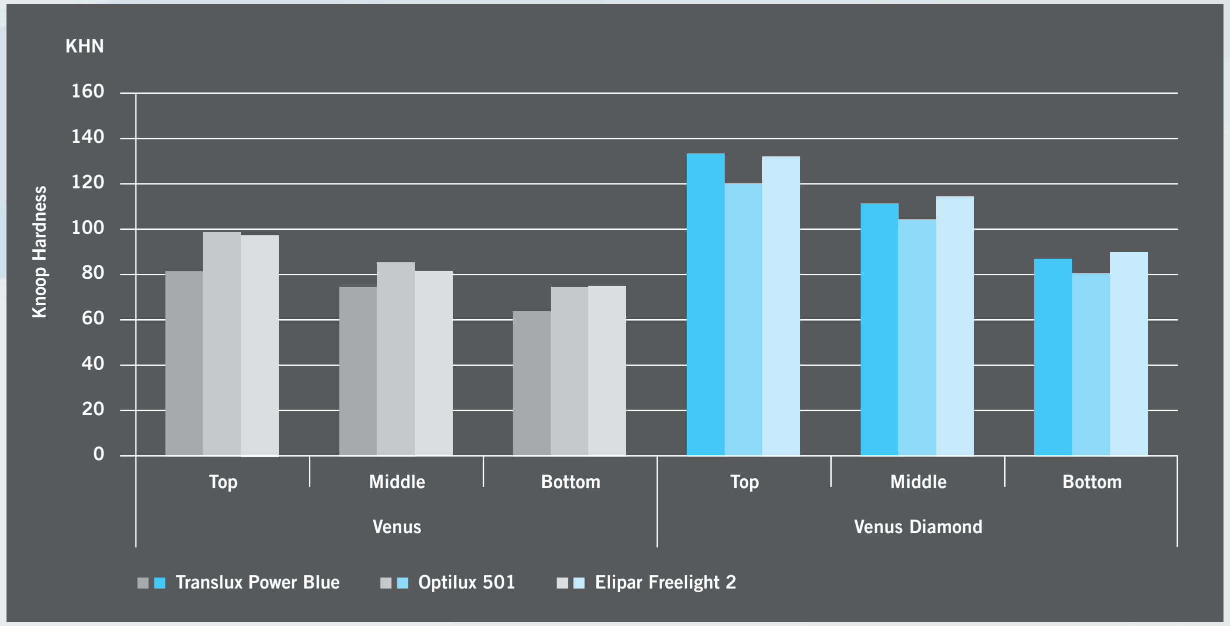
Objective

In the context of this investigation microhardness of composites resulting from different light-curing units was determined.

Materials and Methods

All tests were conducted on standardized class II cavities with gingival margins in bovine dentine. Specimens were restored with Venus Diamond and Venus (both Heraeus Kulzer) and cured with the light curing units Optilux 501 (Demetron/Kerr), Translux Power Blue (Heraeus Kulzer), and Elipar FreeLight 2 (3M ESPE). Each filling material was to be combined with each curing device. Microhardness was measured with a Knoop hardness test at the top, middle and bottom third of the restoration.

Results



Venus Diamond shows superior hardness with every tested light curing system

The occlusal third of the restorations shows with each tested composite and curing unit the highest microhardness. The gingival third reveals in each combination the lowest microhardness.

Conclusion

In comparison, hardness for Venus Diamond is higher than for Venus.

Degree of conversion

During the polymerisation monomers are crosslinking with other monomers to a polymer. During this reaction monomers are opening double bonds to bond to each other (single bonds). The ratio of double bonds to single bonds (= degree of conversion or degree of cure) can be measured.

Remaining single bonds can identify residual (not-cross-linked) monomers or cross linked monomers which have not cross linked with all their functional bonding areas.

The degree of conversion depends on the type of monomer, filler composition, initiator system and light curing procedure[17].

Left picture: High cross linking for increased mechanical strength of the cobweb
Right picture: Lower cross linking rates lead to impaired mechanical strength

Low conversion rates show two major disadvantages. Firstly, mechanical material properties are decreased[18]. Polymers with high degree of conversion resists better mechanical forces during mastication due to the fact that strength and hardness increases. Further, materials with high degree of conversion have a reduced ability to dissolve in liquids and the water sorption (swelling) of those composites is also reduced which may have also a positive influence on mechanical strength and colour stability.

The second problem is a risen quantity of residual monomers in the composite which might have the potential of sensitisation of adjacent soft tissues[19].

Some monomers like Bis-GMA are very stiff and show a lower degree of conversion[20]. This is caused by the reduced ablility of stiff monomers to rotate and match with other monomers during polymerisation.

Due to the usage of high reactive and elastic cross linkers in Venus Diamond and Venus Diamond Flow, both materials exhibit high degrees of conversion.

[17] Peutzfeldt A, Asmussen E: Investigations on polymer structure of dental resinous materials. Trans Acad Dent Mater 18, 2004: 81–104.
[18] Lovell LG, Newman SM, Bowman CN: The effects of light intensity, temperature, and comonomer composition on the polymerization behavior of dimethacrylate dental resins. J Dent Res 78, 1999: 1469–1476.
[19] Carmichael AJ, Gibson JJ, Walls AW: Allergic contact dermatitis to bisphenol-A-glycidyldimethacrylate (BIS-GMA) dental resin associated with sensitivity to epoxy resin. Br Dent J 183, 1997:297–298.
[20] Sandner B, Baudach S, Davy KWM, Braden M, Clarke RL: Synthesis of Bis-GMA derivatives, properties of their polymers and composites. J Mater Sci Mater Med. 1997, 8(1):39-44.

Venus® Diamond – In vitro studies

Degree of conversion

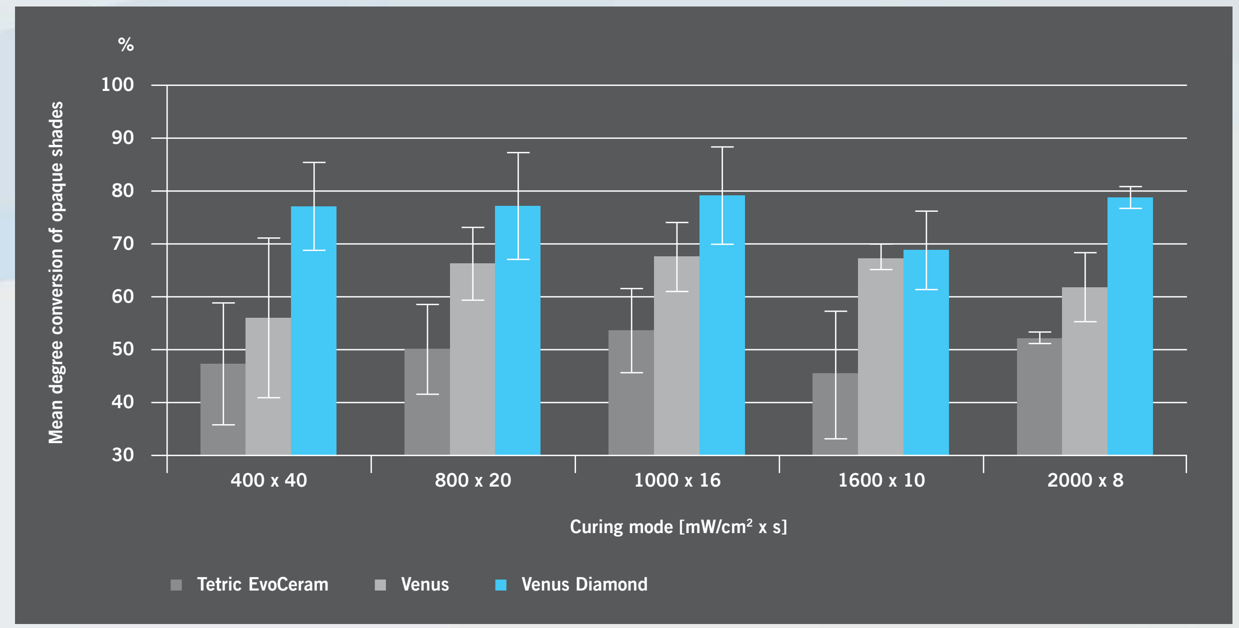
Relevance of Different Polymerisation Methods On Light-curing Composites. Conversion Degree

Source
Cerutti F, Acquaviva PA, Gagliani M, Madini L, Depero LE and Cerutti A
University of Brescia and University of Milan, Italy
J Dent Res 88 (Spec Iss A): 301, 2009 (www.dentalresearch.org)

Objective
Aim of this study was to detect the polymerisation method which results in the highest conversion degree. Therefore, different time-power-combinations were evaluated.

Materials and Methods
150 disks (6 mm in diameter, 1 mm thick) were prepared using opaque and translucent shades of the composite materials Venus Diamond, Venus (both Heraeus Kulzer) and Tetric EvoCeram (Ivoclar Vivadent). The material was polymerised with a halogen lamp in following combinations: 400 mW/cm² for 40 s, 800 mW/cm² for 20 s, 1000 mW/cm² for 16 s, 1600 mW/cm² for 10 s and 2000 mW/cm² for 8 s. The degree of conversion was determined by Micro-Raman spectroscopy.

Results



Venus Diamond reveals nearly 80% of conversion rate

Conclusion
This study shows that composite materials based on the new monomer TCD-DI-HEA (Venus Diamond) reach remarkably high conversion degrees. Degree of conversion in this study was slightly higher for opaque shades.

Venus® Diamond flow – In vitro studies

Degree of conversion

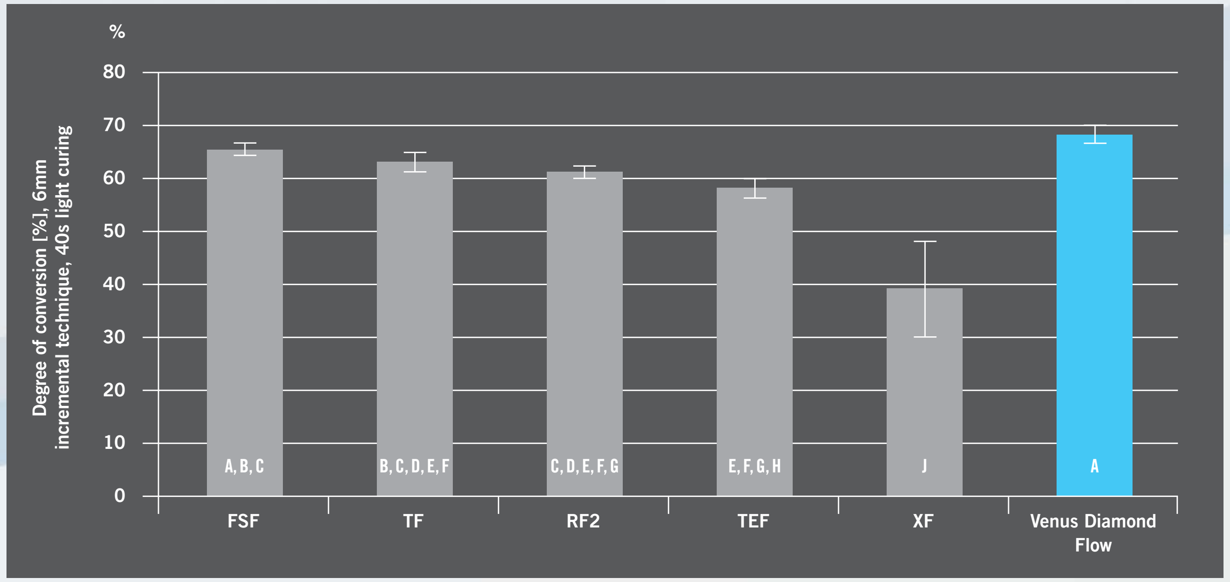
Study report: Bis-GMA free flowable nano-hybrid composite

Source
Ilie N
Ludwig-Maximilians-University Munich, Germany
October 2009. Data on file

Objective
Purpose of the research project was to measure the degree of conversion of different flowable composites: Venus Diamond Flow (VDF, Heraeus Kulzer), Filtek Supreme XT/Plus Flow (FSF, 3M ESPE), Tetric Flow (TF, Ivoclar Vivadent), Tetric EvoFlow and Tetric Flow (TEF, TF, both Ivoclar Vivadent), x-flow (XF, Dentsply) and Revolution Formula 2 (RF2, Kerr).

Materials and Methods
Composite was filled into molds with a height of 6 mm. The molds were either bulk or in 2 mm increments filled. Thereafter specimens were light cured for 20 or 40s. Degree of conversion was determined with FTIR-Spectrometer.

Results



Venus Diamond Flow exhibits highest crosslinking rate

No significant differences between specimens with same letters were found.

Venus Diamond Flow exhibits at each tested curing time the highest level of degree of conversion in comparison with the other tested flowable composites: After 40 s Venus Diamond reveals a degree of conversion of 68.9% (±1.3) for the incremental and 59.4% (±2.1) for the bulk filling technique.

Conclusion
Venus Diamond Flow and Filtek Supreme XT Flow show the highest degree of conversion in this study.

Radiopacity

Radiopacity is of prime importance for composites and in particular for flowables[21]. High radiopacity values simplify to distinguish between sound tooth structure, restorations and carious lesions or voids.

Especially flowables with a low radiopacity have the risk to be mistaken for carious lesions/secondary caries if used as cavity liner. The consequence would be a needless destruction of sound tooth structure and/or sufficient restorations.

Hence, Venus Diamond and Venus Diamond Flow were developed with a high radiopacity to allow optimal and reliable diagnostics.

X-ray of molar:
left restoration: Venus Diamond Flow Baseliner & Filtek Supreme Plus/XT
right restoration: Venus Diamond Flow Baseliner & Venus Diamond

[21] Ergücü Z, Türkün LS, Onem E, Güneri P: Comparative radiopacity of six flowable resin composites. Oper Dent. 2010 Jul-Aug;35(4):436-40.

Venus® Diamond – In vitro studies
Radiopacity

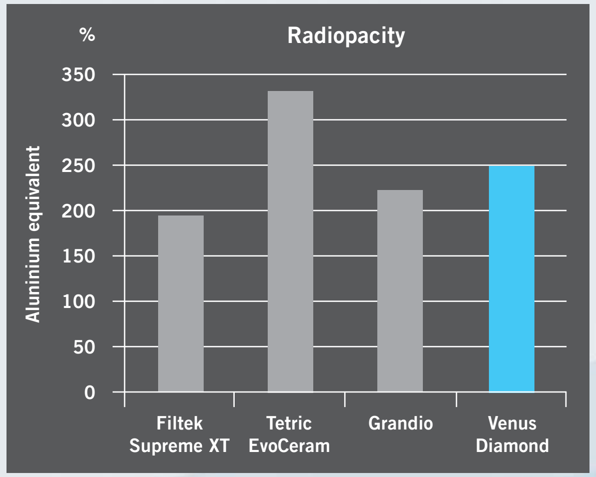
X-ray opacity of resin composites

Source
Finger WJ, University of Cologne, Germany
Report 2008. Data on file

Objective
Aim of this study was to determine x-ray opacity of four composite materials.

Materials and Methods
Radiopacity of the composite materials in question was measured as percentage of radiopacity of aluminum. In order to compare directly, a radiograph was taken of all specimens in comparison to a range of aluminum plates of varying thicknesses. Afterwards the aluminum-equivalent of each composite was determined.

Results



Excellent radiopacity of Venus Diamond

Conclusion
The highest radiopacity is measured for Tetric EvoCeram (Ivoclar Vivadent), followed by Venus Diamond (Heraeus Kulzer), Grandio (Voco) and Filtek Supreme XT (3M ESPE).

Venus® Diamond flow – In vitro studies
Radiopacity

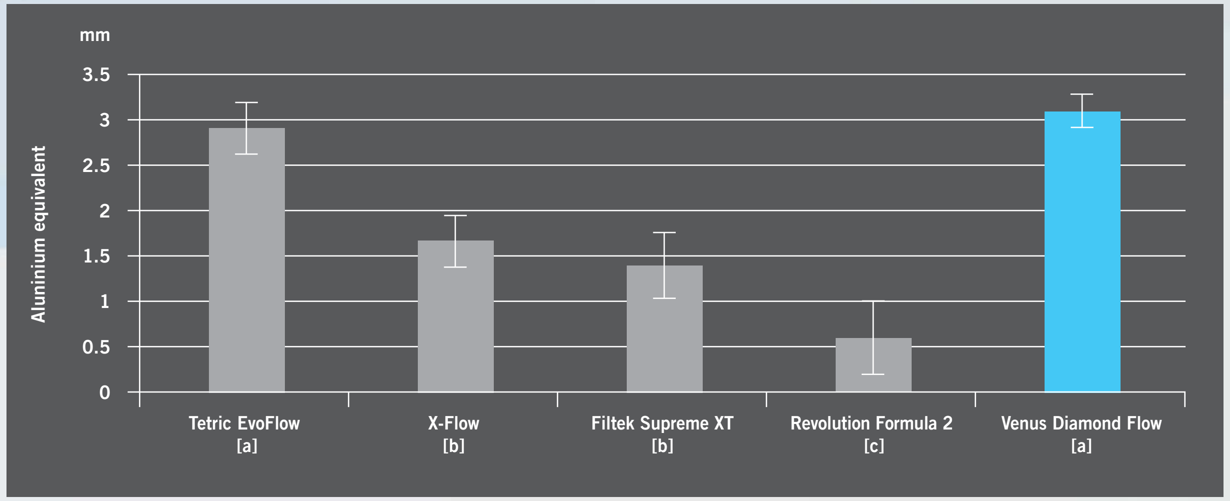
Radiopacity of an experimental flowable composite compared to four currently available flowable composites

Source
Yaman P, University of Michigan, Ann Arbor, USA
Test report 2009. Data on file

Objective
Purpose of the study was to determine the radiopacity of 5 flowable composites: Venus Diamond Flow (Heraeus), Revolution Formula 2 (Kerr), X-Flow (Dentsply), Filtek Supreme XT (3M ESPE) and Tetric Evo-Flow (Ivoclar Vivadent).

Materials and Methods
The radiopacity of the five flowable composites was determined according to ISO guideline 4049.

Results



Venus Diamond Flow shows maximum radiopacity

No significant differences between specimens with same letters were found.

Conclusion
According to ISO guideline 4049 is a composite material is considered radiopaque if the aluminum equivalent value of the material is greater than 1 mm. Venus Diamond Flow and Tetric EvoFlow from Heraeus Kulzer show the highest radiopacity.

Ambient light sensitivity

It is advantageous for a dental resin composite to have a prolonged working time under the light conditions in a dental office.

Particular when complex occlusal morphologies need to be reconstructed the material needs to illustrate a good sculptability and an extended working time.

Venus Diamond features a low sensitivity to ambient light in the dental office. This allows the dentist extra time for the modeling of the anatomical tooth structures. Thereby the time for the time-consuming shaping of the cured restoration is reduced which leads to shorter chair times

Venus® Diamond – In vitro studies

Ambient light sensitivity

Ambient light sensitivity test

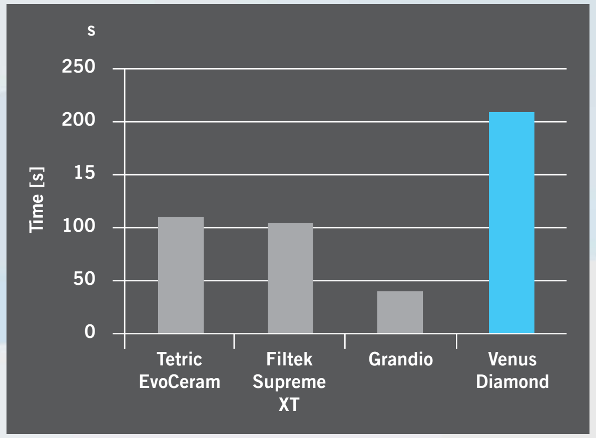
Source

R&D, Heraeus Kulzer GmbH, Wehrheim, Germany. Data on file

Objective

Long working time is a major criterion for the dentist's convenience in handling composite materials. Aim of the study was to evaluate the ambient light sensitivity of Venus Diamond and 3 other composites.

Results



Premier resistance to ambient light in Venus Diamond

Conclusion

In the experiment Venus Diamond has the longest working time with 210 s prior polymerisation. This enables the practitioner to sculpt the restorations surface convenient avoiding excessive shaping after curing.

Materials and Methods

Composite samples of Venus Diamond (Heraeus Kulzer) Filtek Supreme XT (3M ESPE), Grandio (VOCO) and Tetric EvoCeram (Ivoclar Vivadent) were placed on a glass plate. Afterwards irridation of the samples for different times by a Xenon lamp (8000 lx) was performed according ISO 4049 before each sample was covered by a second glass plate with a shearing movement to create a thin layer. This layer was examined for homogeneity.

Water sorption and water solubility

Resin composites tend to absorb a certain amount of water. Minimal water sorption can be beneficial as it helps to relax shrinkage stress[22]. But higher sorption rates lead to an expansion of the restoration which may cause even more stress, fractures and/or postoperative sensitivities.

Rigatoni as example for water sorption (before and after cooking)

For this reason it is favorable for a composite to absorb as less water as possible.

An increased water solubility of a resin composite breeds mechanical degradation and leaking of residual monomers which may causes sensibilities of the surrounding soft tissue. As these both effects are unwished, water solubility of a resin composite need to be very low.

Venus Diamond shows both low water sorption and minimised water solubility.

Left picture: Evervescent tablet
Right picture: Completely dissolved tablet in water representing a high water solubility.

[22] Feilzer AJ, DE Gee AJ, Davidson CL: Relaxation of Polymerization Contraction Shear Stress by Hygroscopic Expansion. J Dent Res 69(1), 1990:36-39.

Venus® Diamond – In vitro studies
Water sorption and water solubility

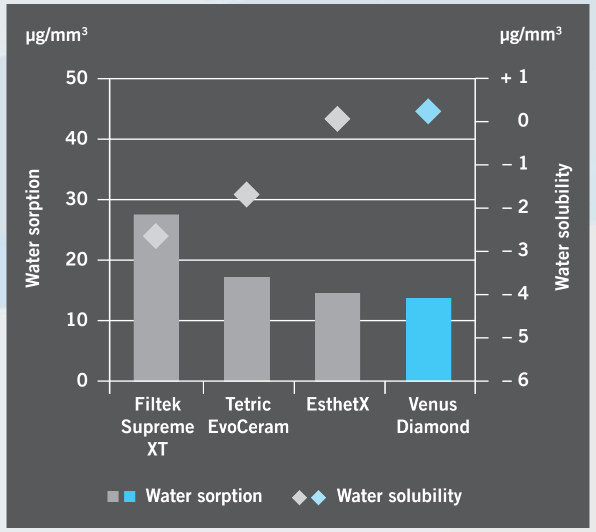
Comparative investigation of an experimental composite and three other composites

Source
Koplin C, da Silva Rodrigues G, Jaeger R, Fraunhofer Institute
Test report 2008. Data on file

Objective
The aim of the following study was to test the water sorption as well as the water solubility of Venus Diamond and three other composites.

Materials and Methods
The mass of 5 dry samples of each composite (Venus Diamond, Tetric EvoCeram, EsthetX, Filtek Supreme XT) was determined. Then the samples were kept under water for 7 days and weighed again measure the amount of absorbed water. Recurred dryings and weightings were used to evaluate water solubility.

Results



Venus Diamond exhibits lowest water solubility and sorption

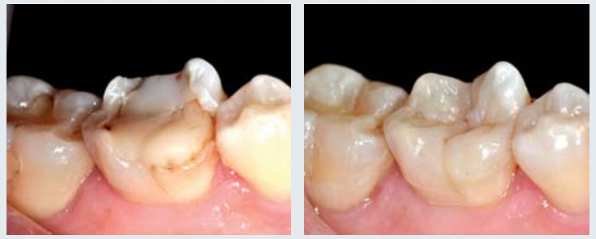
Conclusion
All composites are passing the ISO 4049 requirements for water sorption and water solubility of dental resin composites. Venus Diamond tends to absorb the least water of all tested composites in this test.

Wear Resistance

A restoration is exposed to various abrasive substances like food particles, toothpastes and contact to surfaces from antagonistic teeth.

Early dental composites were not abrasion stable. The consequence was massive worn restorations which lost initial occlusal functional morphologies.

The aim of modern universal composites is to minimize the wear of the restoration in order to overcome these problems and to allow the dental practitioner long-lasting reconstructions of functional surfaces especially when restoring large occlusal areas in posterior teeth[23].



Left picture: Example of a worn restoration.
Right picture: After restoration with Venus Diamond. Courtesy of Wolfgang Boer, Euskirchen, Germany.

Venus Diamond exhibits in various tests excellent wear resistance properties. Even Venus Diamond Flow reveals good abrasion stability despite the primary focus of the development of flow materials is not abrasion stability.

In the following are the results of different abrasion tests presented like toothbrush abrasion, chewing simulation and the 3-media abrasion in a poppy seed medium which represents also the influence of abrasive food particles.

[23] Yesil ZD, Alapati, S, Johnson W, Seghi RR: Evaluation of the wear resistance of new nanocomposite resin restorative materials. J Prosthet Dent. 2008 Jun;99(6):435-43.

Venus® Diamond – In vitro studies

Wear resistance

Resistance of nanofill and nanohybrid resin composites to toothbrush abrasion with calcium carbonate slurry

Source

Suzuki T, Kyoizumi H, Finger WJ, Kanehira M, Endo T, Utterodt A, Hisamitsu H, Komatsu M, Showa University School of Dentistry, Tokyo, Japan
Dental Materials Journal 2009; 28(6): 708–716

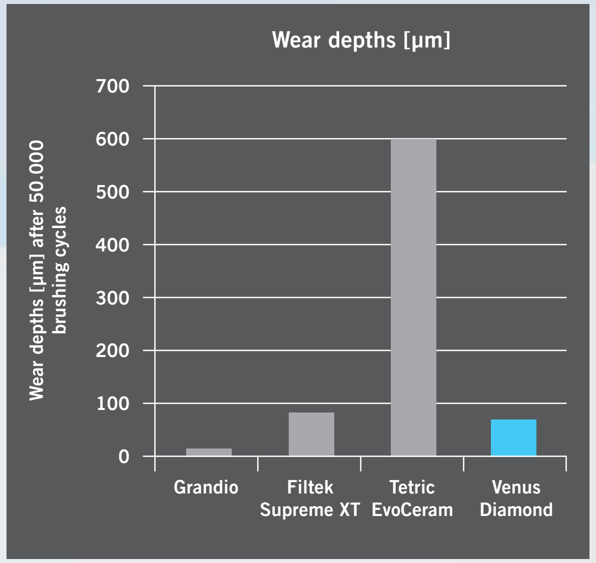
Objective

Aim of this study was to determine the effects of toothbrush abrasion. In this context the depths of abrasion was determined.

Materials and Methods

A custom made abrasion testing machine (Tokyo Giken Inc., Tokyo, Japan) served to simulate toothbrush abrasion. The test was conducted with Filtek Supreme XT (3M ESPE), Grandio (Voco), Tetric EvoCeram (Ivoclar Vivadent), and Venus Diamond (Heraeus Kulzer). Firstly, 20 discs of each resin composite were prepared. After curing and grinding on wet SiC paper, the specimens were fixed on holders and mounted under lines of reciprocating toothbrushes. The abrasive effects of toothpaste were simulated by immersing the specimens in calcium carbonate slurry. Measurements were taken during 50.000 brushing cycles.

Results



Venus Diamond exposes respectable toothbrush abrasion stability

Differences between the composites are siginificant ($p < 0.001$).

Conclusion

Toothbrush abrasion of the four nanofiller composites results in significantly different wear rates. The test shows that abrasion depth rose linearly with the numbers of toothbrushing cycles. Venus Diamond demonstrates a reasonably moderate wear.

Venus® Diamond – In vitro studies
Wear resistance

Two media abrasion (chewing simulation); Three media abrasion (ACTA method)

Source
R&D, Heraeus Kulzer, Wehrheim, Germany
Test report 2008. Data on file

Objective
The purpose of this test was to investigate the wear behaviour of six different composites.

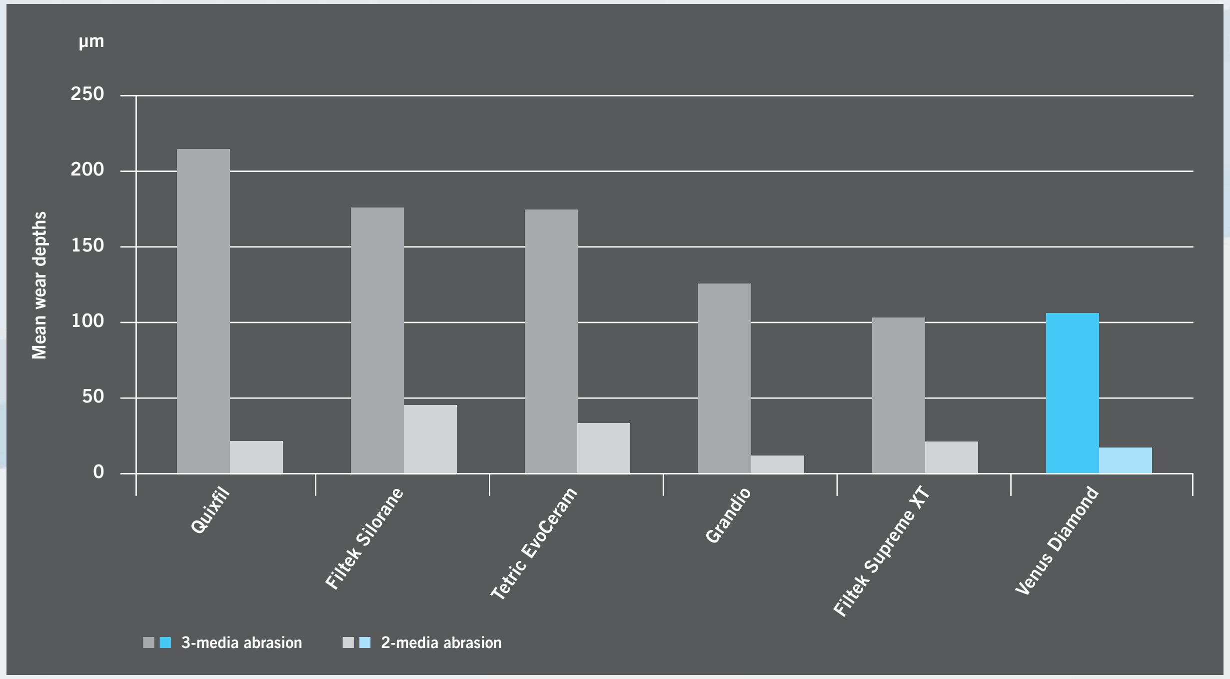
Materials and Methods
Specimens of Venus Diamond (Heraeus Kulzer), Filtek Supreme (3M ESPE), Grandio (Voco), Tetric EvoCeram (Ivoclar Vivadent), Filtek Silorane (3M ESPE) and Quixfil (Dentsply) were prepared.

Two-Media-Abrasion test samples were positioned in a chewing simulator and a thermo-mechanical load was applied (water, temperature 5°–55°C, 50 N for 1,200,00 cycles).

Three-Media-Abrasion was conducted according the ACTA method in a poppy seed medium (300,000 cycles).

Evaluation of wear depths for both tests was done with a surface laser scanner.

Results



Test results confirm outstanding wear resistance of Venus Diamond

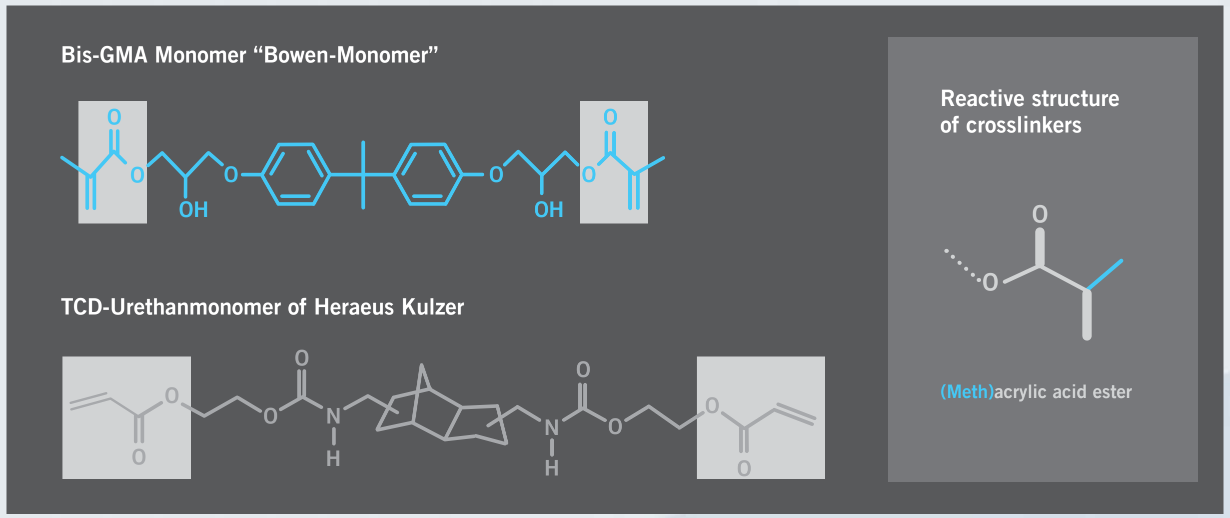
Conclusion
Venus Diamond reveals an excellent wear resistance. The abrasion depths of Venus Diamond are in both tests very low.

In vitro studies
Compatibility to adhesives

Compatibility to adhesives

Compatibility between adhesive and composite is the precondition for successful restorations which need to remain stable for long periods.

Despite the new chemical formula of Venus Diamond and Venus Diamond Flow both resin composites are fully compatible to methacrylate adhesive systems and composites. The cross linking areas of TCD-Urethane and EBADMA are identical to the conventional BIS-GMA-TEGDMA-system.



The reactive structure of the TCD monomer is identical to other methacrylates

Venus® Diamond – In vitro studies

Compatibility to adhesives – Shear bond strength

Evaluation of compatibility of a new nano-hybrid composite to adhesives

Source

Hoffmann M, Schweppe J, Utterodt A, Kastrati A, Schaub M, Erdrich A, R&D, Heraeus Kulzer, Wehrheim, Germany
J Dent Res 88 (Spec Iss A), 1810, 2009 (www.dentalresearch.com)

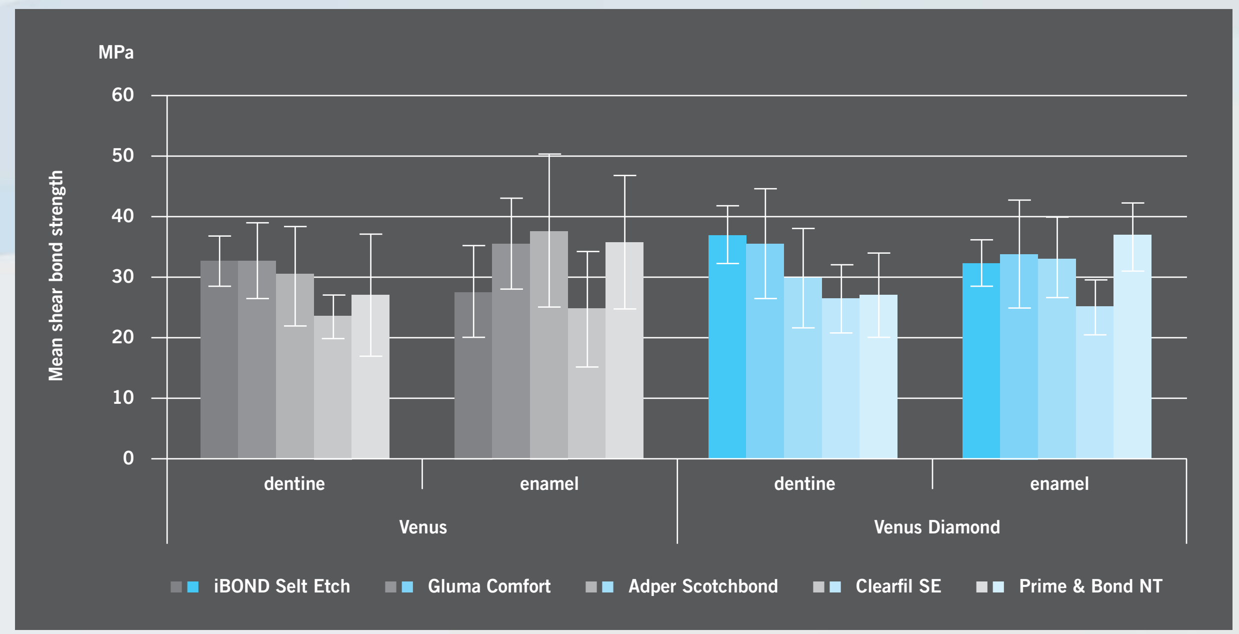
Objective

The objective of this study was to evaluate the compatibility of Venus Diamond and Venus (both Heraeus Kulzer) to different adhesive systems by determination of the shear bond strength (SBS) to human dentine and enamel.

Materials and Methods

Shear bond strength (Ultradent method) was determined on extracted human molars. Adhesives were applied according to manufacturer's instruction for use. The adhesives used in this study were iBond Self Etch, Gluma Comfort Bond + Desensitizer (both Heraeus Kulzer), Adper Scotchbond Multipurpose (3M ESPE), Clearfil SE Bond (Kuraray) and Prime & Bond NT (Dentsply). Venus composite and Venus Diamond composite, were bulk filled in cylindrical plastic molds and cured. SBS was determined after 24h water-storage of specimens at 37°C.

Results



Venus Diamond is fully compatible to conventional adhesives

Conclusion

Venus Diamond is compatible to all adhesives used in this study. Venus Diamond has a similar compatibility to the tested adhesives as the longtime established Venus composite.

Venus® Diamond – In vitro studies
Compatibility to adhesives – Shear bond strength

Interactions of self-etch adhesives with resin composites

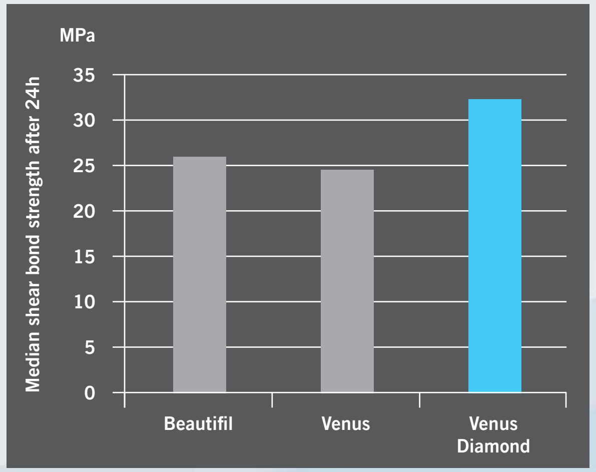
Source

Kurokawa R, Finger WJ, Hoffmann M, Endo T, Kanehira M, Komatsu M, Manabe A, Division of Orthodontics, Niigata University, Japan
Journal of Dentistry 35, 2007: 923-29

Objective

Aim of this study part was to investigate shear bond strength using the combination of four self-etch adhesives and three resin composites.

Results



Combination of iBond Self Etch and Venus Diamond leads to highest shear bond strength

Shear bond strength of Venus Diamond was significantly superior to the other combinations between iBOND Self Etch and the tested composites after 24h.

Conclusion

No correlation is found between shear bond strength and marginal cavity adaptation.

Materials and Methods

Interactions were studied between one two-step FL BOND II (Shofu) and three one-step products Fluoro Bond Shake One (Shofu), iBond Total Etch and iBOND Self Etch (both Heraeus Kulzer), and the composites Beautifil (Shofu), Venus and Venus Diamond (both Heraeus Kulzer). For all 12 combinations shear bond strength were determined on human dentine.

Venus® Diamond – In vitro studies
Compatibility to adhesives – Marginal integrity

Effects of dentin adhesives on cavity adaptation of universal composites

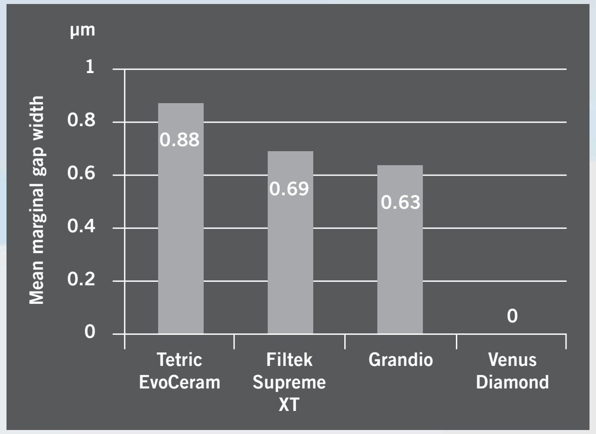
Source

Kanehira M, Manabe A, Finger WJ, Hoffmann M, Komatsu M, Tohoku University Graduate School of Dentistry, Japan
J Dent Res 88 (Spec Iss A): 501, 2009 (www.dentalresearch.org)

Objective

Aim of this investigation was to determine the marginal performance of four low-shrinkage resin composite restorations, bonded with three alternative dentin adhesives to cylindrical butt-joint dentin cavities.

Results



No marginal gaps with Venus Diamond and iBOND Elf Etch

Venus Diamond was the only composite which presents in combination with iBOND Self Etch only gap free restorations in this test. Filtek Supreme shows 2 gap free restorations, Grandio 5 and Tetric EvoCeram 3 gap free restorations. Venus Diamond was significantly better than Filtek Supreme and Tetric EvoCeram.

In the iBOND Total Etch group is not a significant difference observed between the composites. The widest gap found in this study was 2.5 µm.

Materials and Methods

8 samples of Venus Diamond (Heraeus Kulzer), Filtek Supreme XT (3M ESPE), Grandio (VOCO) and Tetric EvoCeram (Ivoclar Vivadent) were evaluated in combination with each of the three adhesives iBond Self Etch, iBond Total Etch (both Heraeus Kulzer) and one experimental self etch adhesive on extracted human molar teeth. The maximum marginal gap widths in µm were measured

Conclusion

Overall, regarding the cavity size and geometry, the marginal performance of the universal resin composite/adhesive combinations tested was satisfactory. The most promising results were obtained with Venus Diamond in combination with iBOND Self Etch and the experimental all-in-one adhesive.

In vitro studies
Aesthetics

Aesthetics

As mentioned above, the aesthetic aspect of composite fillings becomes more and more important, patients and dentists expect superior results.

The aesthetic behaviour of a composite is determined by different factors. First of all, the shade system needs to be well adjusted to meet the shades and opacities of the natural tooth. Secondly, the colour adaptation of every shade is also a crucial factor for successful restorations. Further, shades need to be stain resistant because the restoration will be exposed to various potential staining edibles. It has been reported that polishing, low water sorption, a high filler-resin ratio, reduced particle size and hardness, and an optimal filler-matrix coupling system is related to improved stain resistance[24].

Last but not least, the polishability and the long-term gloss stability have a tremendous influence on the aesthetic appearance of a resin composite.

Venus Diamond has an easy understandable shade system with 3 opacities (opaque dentine, universal and incisal) with a broad shade range. The use of nano-particles in Venus Diamond enables perfect colour adaption, convenient polishing and a high, long lasting shine. The stain resistance is improved also due to the tight, cross linked matrix and reduced water sorption.

The following examples demonstrate the excellent aesthetic performance of Venus Diamond and Venus Diamond Flow.

Class IV restorations with Venus Diamond: courtesy of Dr. Sanjay Sethi, London (UK)

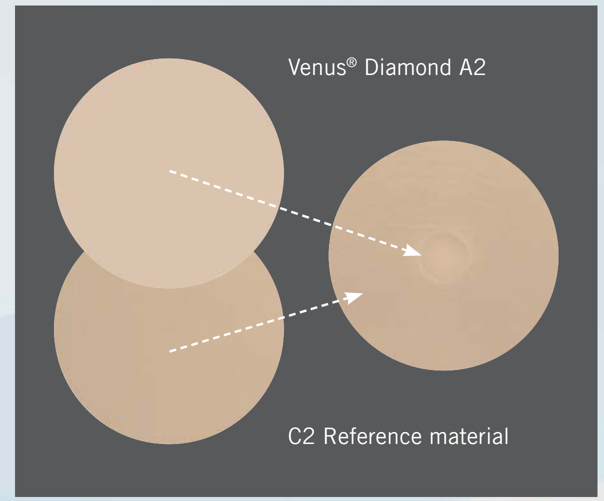
Class IV restorations with Venus Diamond: courtesy of Ulf Krueger-Janson, Frankfurt a.M. (Germany)

Class V restoration with Venus Diamond Flow: courtesy of Ulf Krueger-Janson, Frankfurt a.M. (Germany)

[24] Dietschi D, Campanile G, Holz J, Meyer JM: Comparison of the color stability of ten new-generation composites: an in vitro study. Dent Mater, 1994;10(6):353-62.

Aesthetics – Colour adaptation potential

High aesthetic dental composites need a high colour adaptation potential to enable the dentist to create a matching, nearly invisible restoration. Different shades and translucencies help to adjust the composite restoration to the look of natural teeth.



To demonstrate the effect of colour adaptation a filling with Venus Diamond A2 in a surrounding C2 reference was realised. Venus Diamond's margins are virtually undetectable in this test.

To determine the correct shade of a tooth can be very difficult. Venus Diamond can support in that moment the dental practitioner: Even though a slight different shade was choosen, Venus Diamond has the ability to adapt to the surrounding tooth structure because of its good colour adaptation potential.

The following study depicts this chameleon effect phenomenon.

Venus® Diamond – In vitro studies

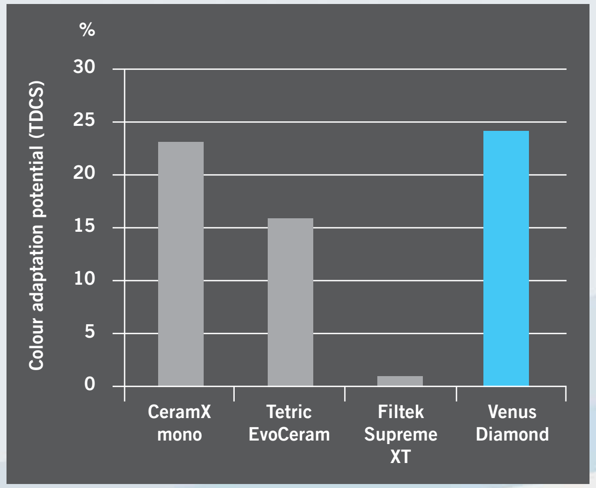
Colour adaptation potential

Translucency – Dependent color shifting of resin composites

Source
Paravina RD, del Mar Perez M, Powers JM, University of Texas, Dental Branch at Houston, USA
IFED 2009, presentation P101

Objective
Purpose of this study was to evaluate the colour adjustment potential (chameleon effect) of resin composites.

Results



Venus Diamond shows the best colour adaptation potential

Materials and Methods
Ring-shaped specimens made of A2 Charisma (Heraeus Kulzer) were prepared. The inner ring holes were filled with composite samples (shade A1 and A3) of Venus Diamond (Heraeus Kulzer), Tetric EvoCeram (Ivoclar Vivadent), Filtek Supreme Plus/XT (3M ESPE) or Ceram X mono (Dentsply Caulk). After polishing, colour adjustment potential was measured using a spectroradiometer.

Conclusion
Venus Diamond exhibits with a colour adaptation potential of 23.9% the best result of the test, followed by Ceram X Mono, Tetric Evo Ceram and Filtek Supreme Plus/XT.

Aesthetics – Stain resistance

Dental restorations are exposed during their lifecycle to various staining aliments.

The staining behaviour of resin materials are presumably related to the materials' composition[25].

This study demonstrates the excellent stain resistance of Venus Diamond.

[25] Gross MD, Moser JB: A colorimetric study of coffee and tea staining of four composite resins. J Oral Rehabil,1977; 4: 311-322.

Venus® Diamond – In vitro studies

Stain resistance

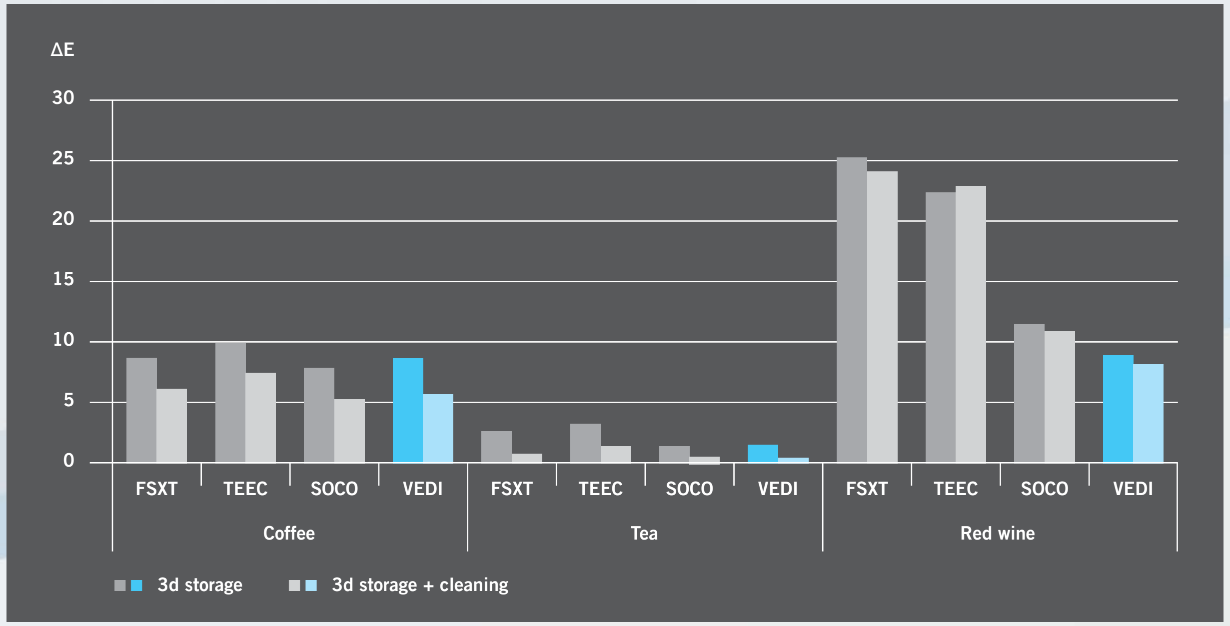
Stain resistance of nanohybrid and nanofiller composites in different media

Source
Utterodt A, Schönhof N, Schneider J, Reischl K, Schaub M, Schweppe J,
R&D Heraeus Kulzer GmbH, Wehrheim, Germany
J Dent Res 89 (Spec Iss B): 3657, 2010 (www.dentalresearch.com)

Objective
The aim of this test was to measure the colour change (ΔE) of different nano-composites after storage in coffee, tea or red wine.

Materials and Methods
Discs of Venus Diamond (VEDI, Heraeus Kulzer), an experimental composite (SOCO, Heraeus Kulzer), Tetric EvoCeram (TEEC, Ivoclar Vivadent) and Filtek Supreme XT (FSXT, 3M ESPE) were respectively stored in coffee, tea, red wine or distilled water (control group). After 24h, 3d and 3d after cleaning by tooth brush colour was measured. Mean values of colour measurements were compared with the control group to determine colour changes (ΔE).

Results



Study represents exceptional stain resistance of Venus Diamond

Conclusion
Venus Diamond and the experimental composite SOCO (both based on a TCD-urethane-matrix) appear less susceptible to discolouration by coffee, tea and especially by red wine, which contains liposoluble pigments and alcohol which is able to support colour penetration by swelling of the polymer networks.

Aesthetics – Polishability and gloss retention

Good polishability is from major importance for universal resin composites.

On the one hand, the polishing result affects the light reflecting characteristics of a composite. Finishing and polishing of resin composite restorations are important steps that enhance aesthetics of restored teeth.

On the other hand poorly polished restorations are susceptible to surface staining, plaque accumulation, gingival irritation, and recurrent caries[26]. Rough surfaces are also uncomfortable for patients and lead to complaints about the restoration which may lead to unneeded replacements of restorations.

The following studies give evidence on the excellent polishing and gloss retention behaviour of Venus Diamond.

[26] Endo et al.: Surface texture and roughness of polished nanofill and nanohybrid resin composites. Dental Materials Journal 2010, 29 (2): 213-23.

Polishability and Roughness of different composites

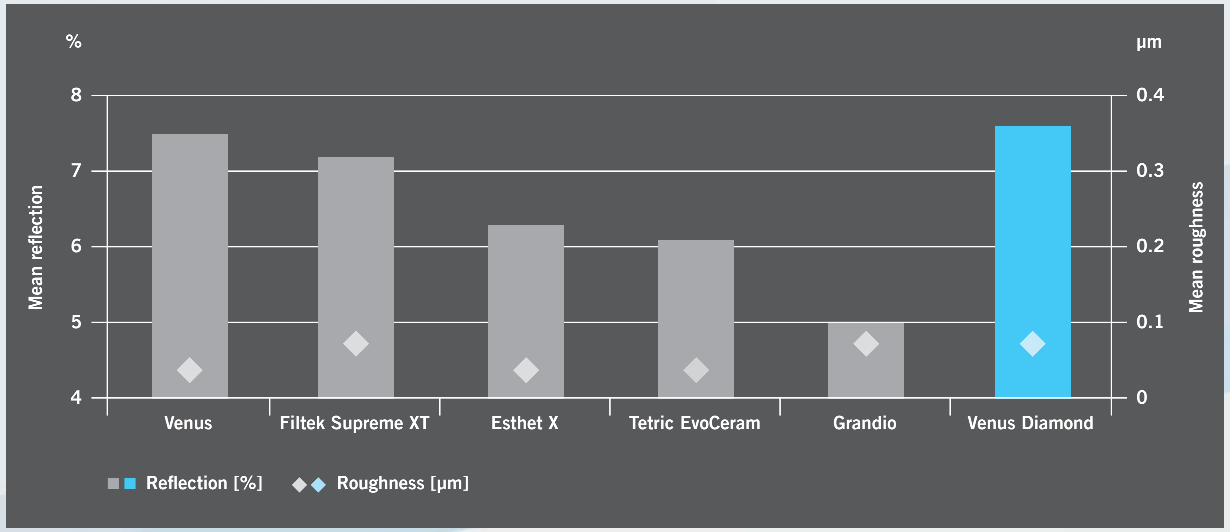
Source
R&D Heraeus Kulzer, Wehrheim, Germany
Test report 2008. Data on file

Objective
Aim of the study was to compare reflection and roughness of six different composites after polishing.

Materials and Methods
Samples of Venus Diamond (Heraeus Kulzer), Filtek Supreme XT (3M ESPE), Grandio (VOCO), Tetric EvoCeram (Ivoclar Vivadent), EsthetX (Dentsply) and Venus (Heraeus Kulzer) were pre-polished for 20s and polished for 40s with the 2-step polishing system Venus Supra (Heraeus Kulzer).

Reflection and roughness were determined by laser scanning.

Results



Convincing polishing performance of Venus Diamond

Conclusion
Polishing of Venus Diamond leads to high reflection values (gloss) and a low roughness which in the range of the other tested composites.

Venus® Diamond – In vitro studies
Polishability and gloss retention

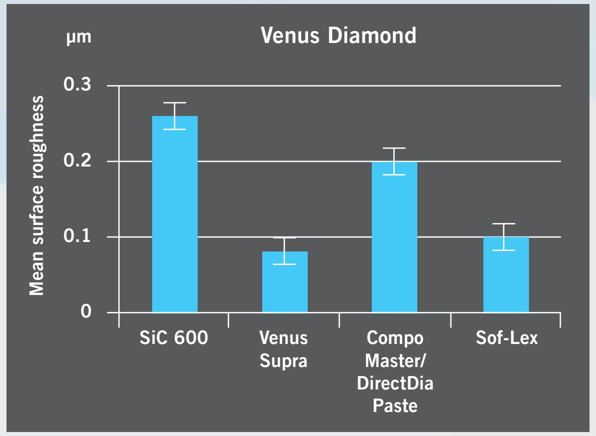
Surface texture and roughness of polished nanofill and nanohybrid resin composites

Source
Endo T, Finger WJ, Kanehira M, Utterodt A, Komatsu M, Tohoku University, Japan
Dental Materials Journal 2010, 29 (2): 213-23

Objective
Purpose of this study was to assess effects of three polishing systems (2-step Venus Supra (Heraeus Kulzer), 3-step Sof-Lex disks (3M ESPE), 2-step CompoMaster/DirectDia Paste (Shofu) on surface texture and roughness of Venus Diamond (Heraeus Kulzer), Filtek Supreme XT (3M ESPE), Grandio (Voco) and Tetric EvoCeram (Ivoclar Vivadent).

Materials and Methods
Composite discs were produced. The surface of the specimen was manually ground on wet SiC paper and acted as a reference for the surface roughness first. Afterwards the surfaces were polished with the different polish systems. Roughness (Ra) was determined by profilometry.

Results



Best polishing combination: Venus Diamond & Venus Supra

Conclusion
Surface roughness was most satisfying after polishing with Venus Supra and Sof-Lex on all four nano filler and nanohybrid resins. With these both mentioned polishing systems roughness values stayed on all tested composites below the accepted 0.2 µm-level.

Polishability and gloss retention

Surface Gloss Stability of Contemporary Composite Resin Materials

Source

Heintze S, Forjanic M, Roulet J-F, R&D Ivoclar Vivadent AG, Schaan, Liechtenstein

J Dent Res 89 (Spec Iss B): 3656, 2010 (www.dentalresearch.com)

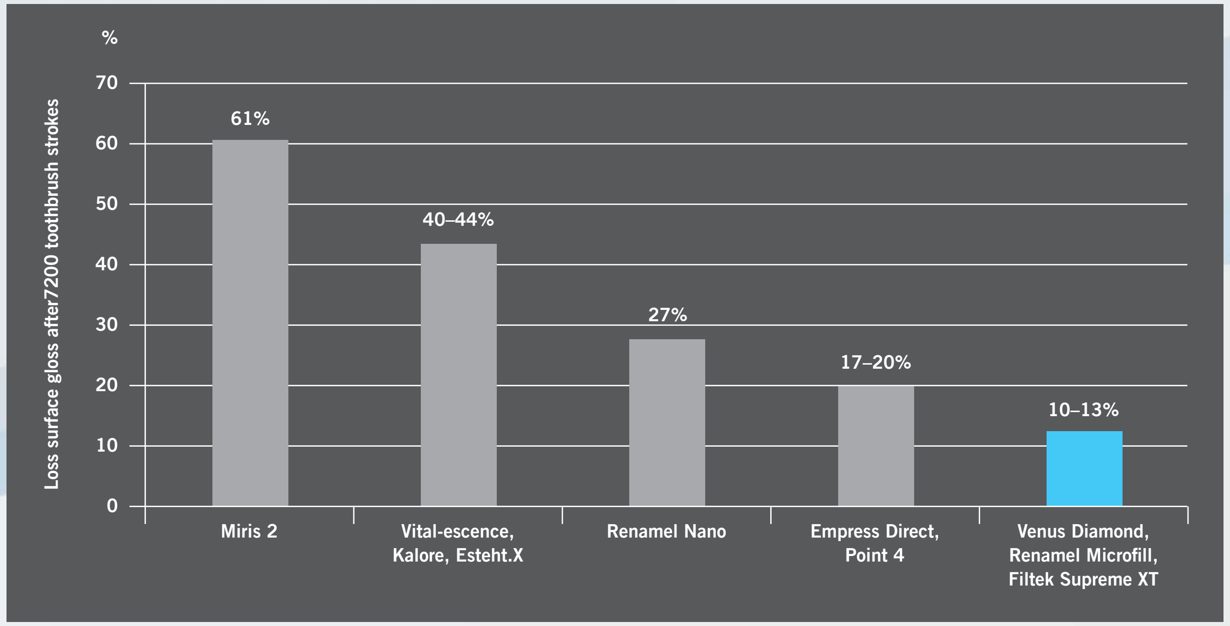
Objective

Evaluation of the surface gloss stability of 10 contemporary composite materials after toothbrush simulation.

Materials and Methods

Specimens (n=8) of following composites were created: Empress direct (Ivoclar Vivadent), Esthet.X HD (Dentsply), Miris 2 (Coltène/ Whaledent), Filtek Supreme XT (3M ESPE), Kalore (GC), Point 4 (Kerr), Renamel Microfill, Renamel Nano (both Cosmedent), Venus Diamond (Heraeus Kulzer) and Vit-l-escence (Ultradent). Samples were polished with SiC paper up to 4000 grit. Thereafter, specimens were submitted to a toothbrush simulation device (Willytec). Before and after 1,800, 3,600, 5,400 and 7,200 strokes of tooth brushing, specimens were measured for surface gloss with a gloss-meter (novo-curve, 60°). The gloss values were compared with a standard and the loss of gloss in relation to after polishing was calculated as percentage.

Results



This study confirms Venus Diamond's paramount gloss stability

Loss of surface gloss was significantly different for the composites with little variation within the same material (mean coefficient of variation 15%). Venus Diamond is in the group of composites which demonstrates the best gloss stability.

Conclusion

For Class IV composite resin restorations or direct veneers clinicians shall select materials with high gloss stability.

In vivo studies

In vitro studies are suitable to evaluate material properties and the materials behaviour under optimised conditions. But laboratory studies can only provide an indication how a dental material performs. Because these studies can simulate reality only with very simplified models.

For this reason clinical trials are inevitable to prove the longevity, aesthetical properties and convenience of application of a restorative material in a real environment.

In the following some selected clinical trials and a handling-evaluation are presented which are confirming the excellent clinical behaviour, the outstanding aesthetic outcome and the superior handling properties of Venus Diamond.

Venus® Diamond – In vivo studies

Class III, IV & V cavities – University of Iowa

Venus Diamond: Class III, IV & V cavities

Source
Vargas M, Kolker J, University of Iowa (USA)
Duration: 36 months
Status: Start in June 2009

Objective
The purpose of this study is to evaluate aesthetic and functional outcomes of anterior restorations.

Materials and Methods
This randomized single blinded split-mouth study compares the clinical performance of Venus Diamond with a comparable universal composite in anterior permanent teeth of 50 patients. Every patient obtains minimum one restoration of each filling material in the anterior region.

Modified USPHS criteria (anatomic form, marginal adaptation, marginal discolouration, colour match, surface roughness/luster, surface staining, caries) and an aesthetic assessment will be evaluated by calibrated blinded observers at baseline, 6, 12, 24 and 36 months follow-up visits.

Results
Study is running. Baseline results are available

Venus® Diamond – In vivo studies

Class V cavities – University of Brescia

24-month clinical evaluation of class-V restorations with two different composites

Source

Barabanti N, Madini L, Cerutti F, Acquaviva A, Cerutti A, University of Brescia (Italy)

J Dent Res 90 (Spec. Iss A), 146, 2011

Duration: 60 months

Status: Study ongoing

Objective

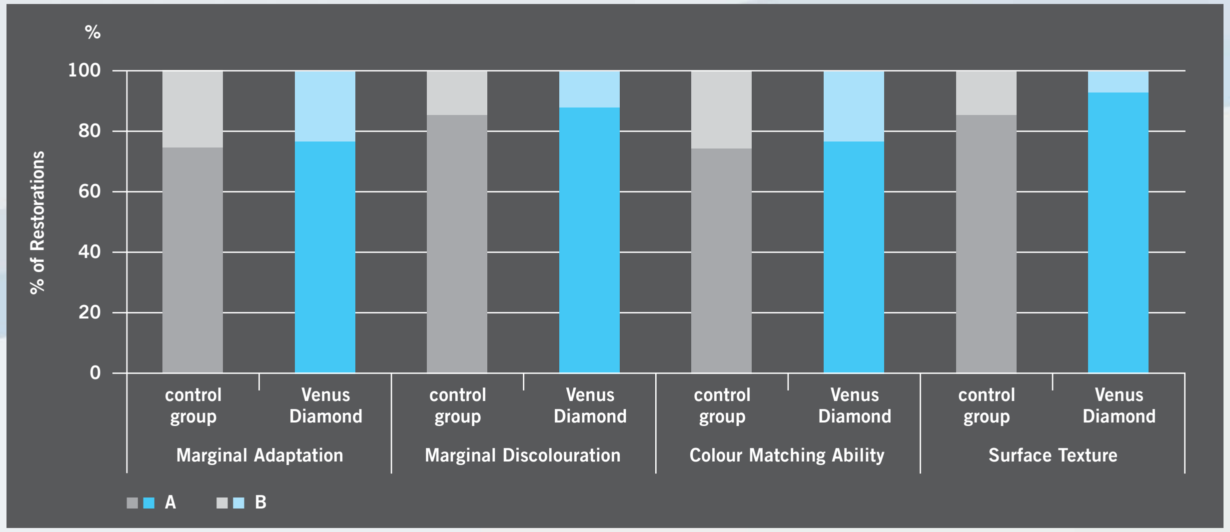
This clinical trial should assess the clinical and aesthetic performance of Venus Diamond in class V restorations and to compare the results with a control group in a controlled randomised split-mouth study design.

Materials and Methods

60 class V restorations were performed by one expert clinician. The used composite and adhesive materials were: Venus Diamond & Gluma Comfort Bond (Heraeus) respectively Ceram X Duo & Prime & Bond NT (Dentsply) as control group. Both groups were polished with Venus Supra (Heraeus).

Clinical evaluations were made by two independent and calibrated investigators. Re-evaluation USPHS and SQUACE criteria based took place at baseline, 6 months, 1 year and also after 24 months. The evaluated criteria were marginal adaptation, marginal discolouration, anatomical form, secondary caries, colour matching ability, surface texture, fracture of restoration, retention, tooth vitality, pulpitis, post-operative sensitivity to temperature and occlusion and the patient satisfaction. The ratings were A, B, C and D for marginal adaptation, A, B and C for marginal discolouration, anatomical form, surface texture and colour matching ability, whereas A represents optimal and B clinical acceptable results.

Results



Venus Diamond reveals a good clinical performance after 24 months in class V cavities

Recall rate after 2 years is 100%. 92% of Venus Diamond restorations and 85% of the control group are smooth, the other surfaces are rated as slightly smooth. Every restoration keeps its anatomic form. All study teeth remain caries-free and all fillings are intact. 95% of the Venus Diamond restorations and 88% of the control restorations are present after 24 months. All study teeth are vital and sound. No tooth exhibits post-operative discomfort. The patient satisfaction is in each group 100%.

Conclusion

Venus Diamond demonstrates a good clinical long-term behaviour in class V restorations after 24 months. The clinical performance behaves as well as the control group.

Venus® Diamond – In vivo studies

Class III & IV cavities – University of Brescia

Study design restorations with composite NEUN

Source

Cerutti A, University of Brescia (Italy)

Study report 2010. Data on file

Duration: 60 months

Status: Study ongoing

Objective

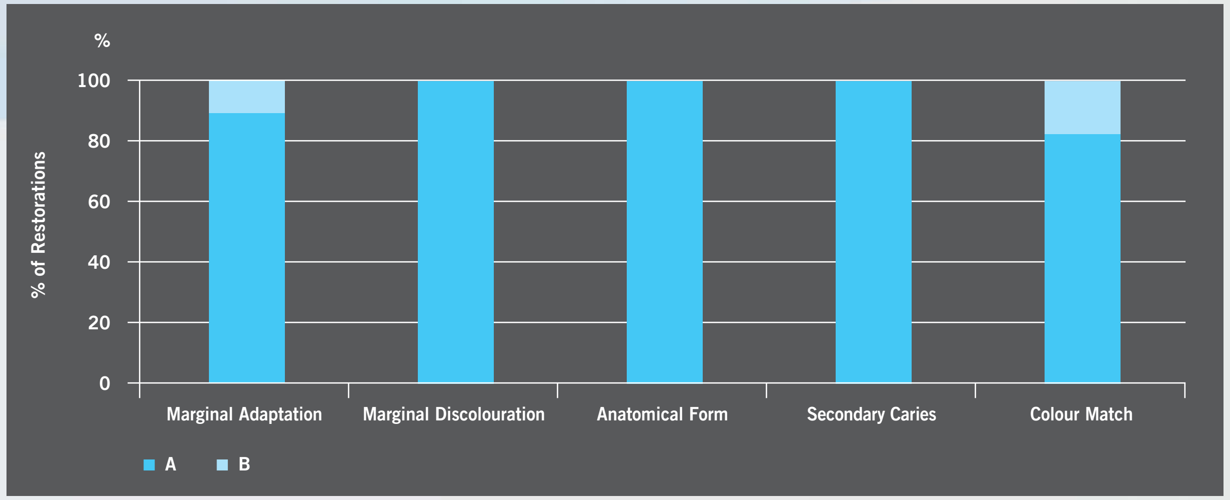
Aim of this in vivo study was to evaluate the clinical and aesthetical performance of Venus Diamond in class III and IV cavities.

Materials and Methods

Within the survey 24 class III and IV restorations have been performed using micro-layering technique of Venus Diamond. Gluma Comfort Bond was used as adhesive system. Restorations were performed by one experienced clinical operator and re-evaluated at baseline, 6,12 and 24 months visits by two independent and calibrated investigators.

The evaluated USPHS and SQUACE criteria were marginal adaption, marginal discolouration, anatomical form, secondary caries, colour matching ability, surface texture, fracture of restoration, retention, interproximal contact, tooth vitality, pulpitis, post-op sensitivity to temperature, post-op sensitivity to occlusion and the patient satisfaction. The ratings were A, B, C and D for marginal adaptation, A, B and C for marginal discolouration, anatomical form, surface texture and colour matching ability, whereas A represents optimal and B clinical acceptable results.

Results



Venus Diamond illustrates an excellent clinical performance after 24 months in class III and IV cavities.

Recall rate after 2 years is 100%. All restorations exhibit an excellent aesthetic result (82% colour match rated as alpha). All restorations are present at the 24 months recall. 82% of the restoration surfaces are smooth, whereas 18% are slightly smooth. None restoration shows fracture, loss of retention or of interproximal contacts. All study teeth are vital and sound. No tooth exhibits post-operative discomfort. The patient satisfaction is 100%.

Conclusion

Venus Diamond demonstrates a good performance after 24 months in anterior restorations. The handling and polishing abilities are rated as outstanding.

Class I & II cavities – SUNY at Buffalo

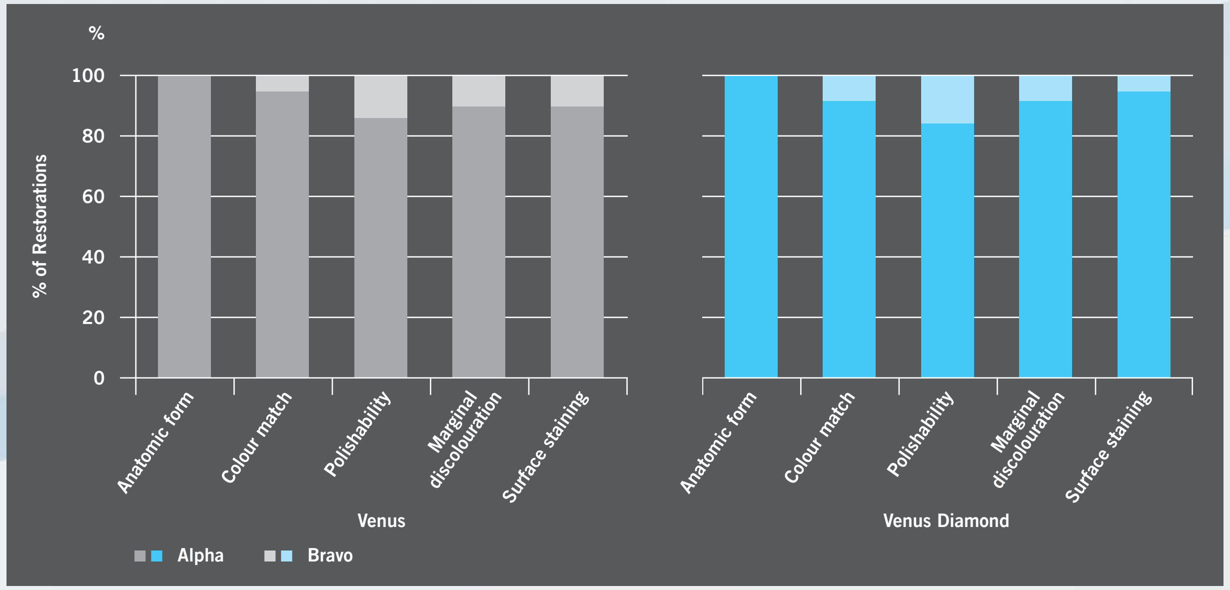
Clinical evaluation of a nano-hybrid composite resin on posterior restorations

Source
Muños CA, Magnuszewski T, State University of New York at Buffalo (USA)
J Dent Res 88 (Spec Iss A): 3243, 2009 (www.dentalresearch.org)
Duration: 24 months
Status: finished

Objective
The purpose of this clinical trial was to evaluate the clinical performance of the universal nano hybrid composite Venus Diamond for use in Class I and II restorations and to compare its clinical performance with the since many years proven Venus composite.

Materials and Methods
This survey was a single-center, split mouth, randomized clinical study in which subjects had at least two posterior restorations placed. 39 Venus Diamond and 38 Venus (both Heraeus Kulzer) restorations in combination with Gluma Comfort Bond + Desensitizer (Heraeus Kulzer) were placed in 30 patients. Re-evaluations were done at baseline, 6, 12 and 24 months. Following modified USPHS-criteria were used for the assessments: anatomic form, colour match, marginal integrity, marginal discolouration, surface staining, gingival index, retention/fracture, secondary caries, proximal contact, polishability and sensitivity.

Results



High level of Venus Diamond after 24 months in posterior teeth

Alpha and Bravo ratings are clinically satisfying. Alpha represents excellence performance and Bravo assessments indicate clinical acceptance.

After 2 years 33 Venus Diamond and 32 Venus restorations were available for re-evaluation.

None of the teeth showed secondary caries during observation period. Marginal integrity at 24 months recall was 87.8 % Alpha and 6.1% Bravo for Venus Diamond. 2 restorations needed minor repair. Marginal integrity for Venus after 2 years was 96.9 % Alpha and 3.1% Bravo. No tooth exhibited sensitivity after 2 years. 3 restorations of each group showed slight gingival inflammation.

Conclusion
This clinical study demonstrates a high level of clinical performance for Venus Diamond. The performance is similar to the long-established Venus.

Class I and II cavities – LMU Munich

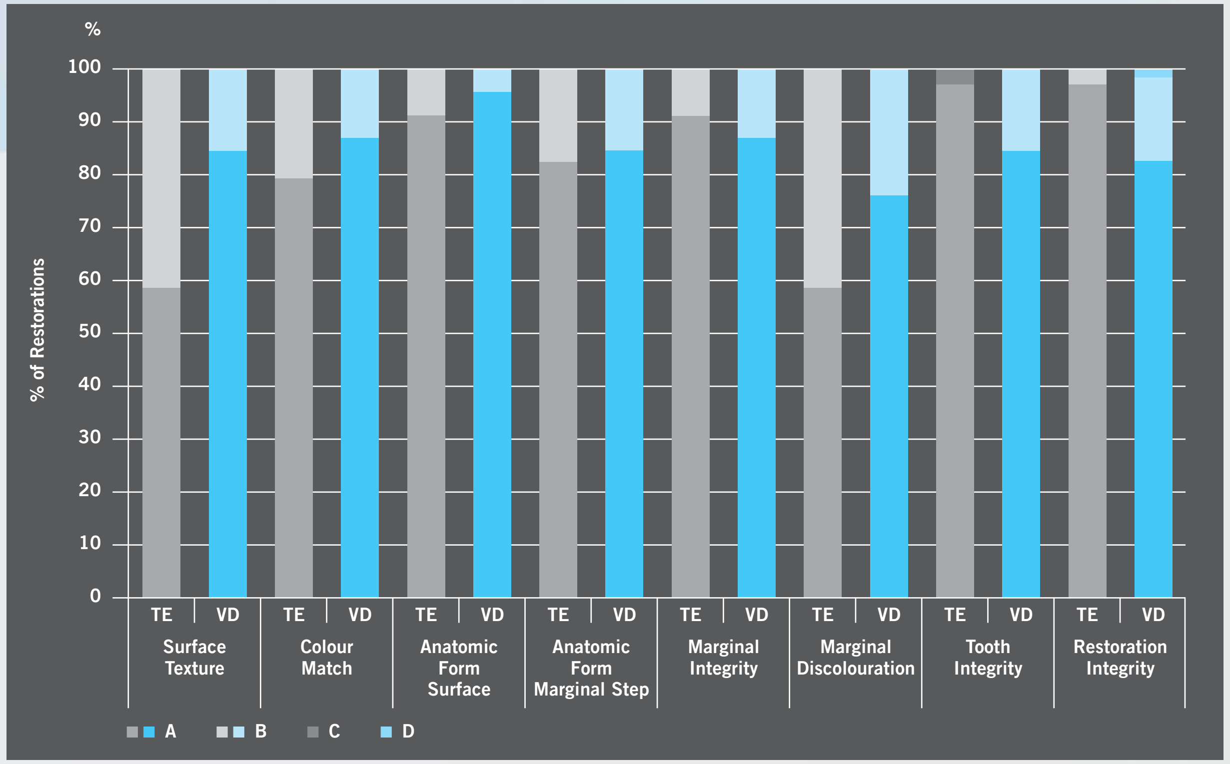
Clinical evaluation of Venus Diamond in posterior cavities (18 months)

Source
Manhart J, Thiessen D, Ern C, Litzenburger A, Okuka A, Rohmer J, Hickel R, LMU Munich, Germany
J Dent Res 90 (Spec Iss C), 151569, 2011

Objective
Determination of the clinical performance of two nano-hybrid composites.

Materials and Methods
48 Venus Diamond and iBOND Self Etch (VD, both Heraeus Kulzer) and 50 Tetric EvoCeram (TE, Ivoclar Vivadent) and Gluma Comfort Bond (Heraeus Kulzer) class I and II restorations were placed by 3 dentists in 71 patients. Clinical assessment at baseline and 18 months was done by 2 independent dentists using USPHS criteria (Surface texture, colour match, anatomic form surface, anatomic form marginal step, marginal integrity, marginal discolouration, tooth integrity, restoration integrity, occlusion, sensitivity, post-op symptoms). After 18 months 46 Venus Diamond and 34 Tetric EvoCeram restorations were available for investigation. Statistic calculations were done by a Mann-Whitney-U-test ($p<0.05$).

Results



All teeth were sensitive and none of the patients reported postoperative symptoms. Venus Diamond showed a significantly better surface texture ($p=0.01$; MW U-test). Fisher's exact test showed no significant differences between Venus Diamond and Tetric EvoCeram concerning the failure rates ($p>0.05$)

Conclusion
Up to 18 months, the clinical performance of Venus Diamond and Tetric EvoCeram exhibits excellent results.

Venus® Diamond – In vivo studies

Handling evaluation by general dental practitioners

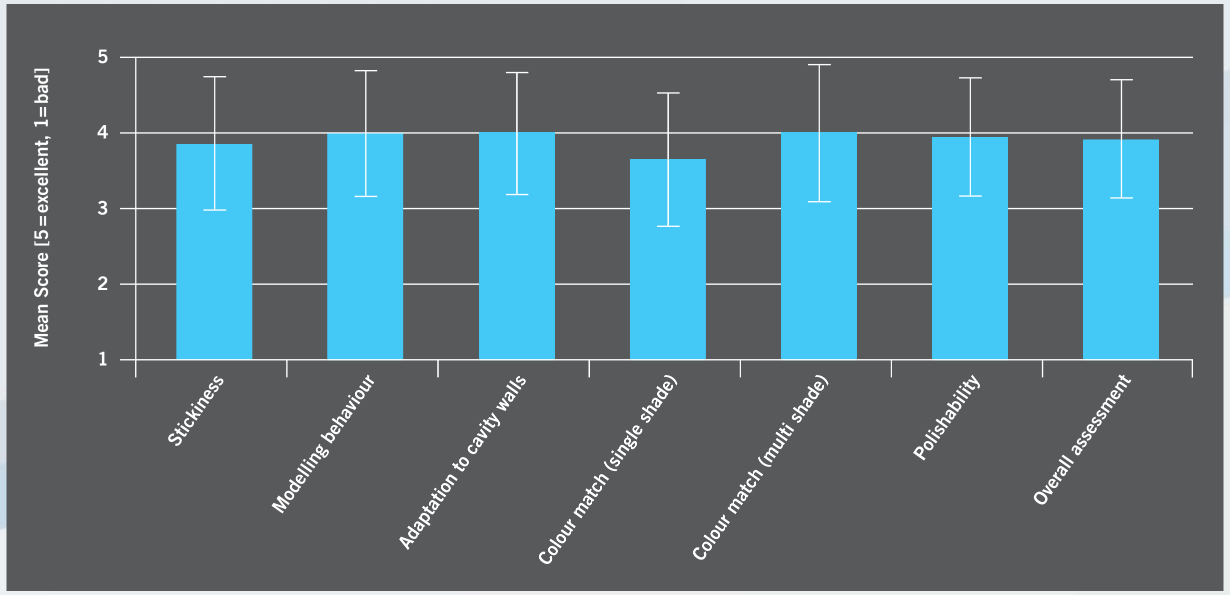
Handling evaluation of a nano-hybrid composite by GDPs in five countries

Source
Schweppe J, Utterodt A, Memmer A, Schaub M, Heraeus Kulzer, Hanau, Germany
J Dent Res 88 (Spec Iss B): 392, 2009 (www.dentalresearch.org).

Objective
This evaluation investigated the handling properties of Venus Diamond, Heraeus Kulzer by General Dental Practitioners (GDPs) from Germany, Italy, UK, France and the U.S.

Materials and Methods
400 GDPs were provided with the composite along with a questionnaire developed to evaluate the handling properties and the colour match. Parameters were stickiness, modelling behaviour, adaptation to cavity walls, consistency, colour match and the polishability and the overall assessment. The evaluation was done by a 5 step scoring system (1=bad, 5=excellent).

Results



Venus Diamond receives outstanding ratings by dental practitioners

271 GDPs returned the questionnaires and 7597 fillings were placed.

94% of the GDPs judged the consistency of Venus Diamond either as suitable or acceptable.

The overall assessment of the material resulted in a mean score of 3.92±0.79 (5=very convenient, 1=very displeasing).

Conclusion
Venus Diamond receives very good ratings regarding its handling properties and colour match ability from the GDPs.

Venus® Diamond Flow – In vivo studies

Class V cavities – University of Brescia

Restorations with Venus Diamond and iBOND Total Etch

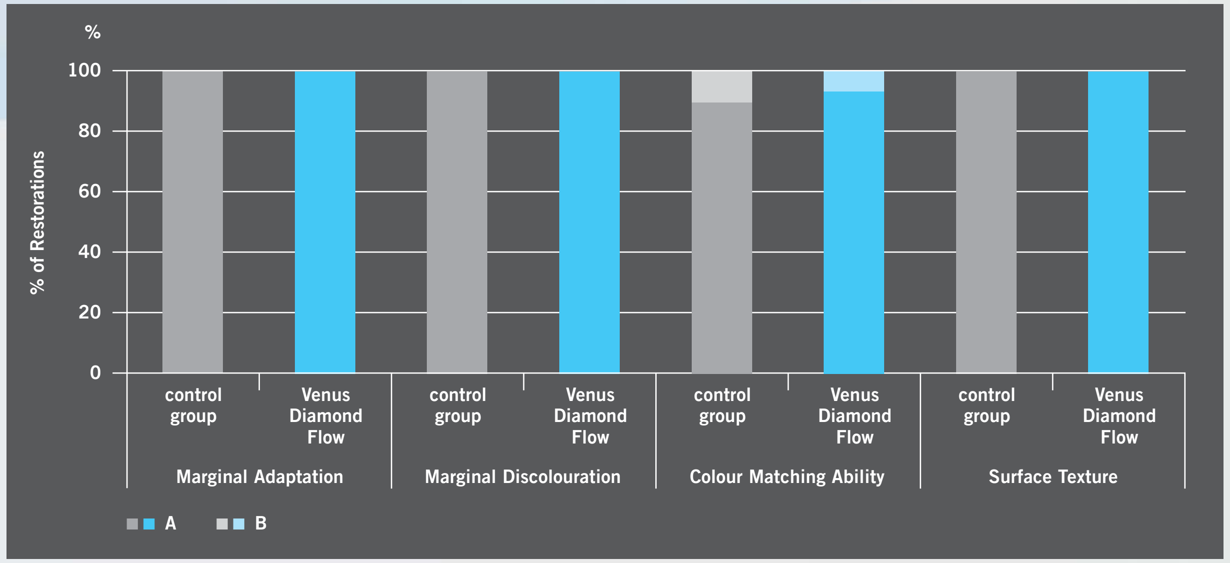
Source
Cerutti A, University of Brescia (Italy)
6-months report 2010. Data on file
Duration: 24 months
Status: ongoing

Objective
This clinical trial assesses the clinical and aesthetic performance of Venus Diamond Flow and iBOND Total Etch in class V restorations in a controlled randomised split-mouth study design.

Materials and Methods
60 class V restorations were performed by one expert clinician. The used composite and adhesive materials were: Venus Diamond Flow & iBOND Total Etch (Heraeus Kulzer) respectively Tetric EvoFlow & ExciTE (Ivoclar Vivadent) as control group. Both groups were polished with Venus Supra (Heraeus Kulzer).

Clinical evaluations were made at baseline and 6 months and will take place also at one and two years. The evaluated criteria were marginal adaptation, marginal discolouration, anatomical form, secondary caries, colour matching ability, surface texture, fracture of restoration, retention, tooth vitality, pulpitis, post-operative sensitivity to temperature and occlusion and the patient satisfaction. The ratings were A, B, C and D for marginal adaptation, A, B and C for marginal discolouration, anatomical form, surface texture and colour matching ability, whereas A represents optimal and B clinical acceptable results.

Results



Promising first clinical results of Venus Diamond Flow

Every restoration keeps its anatomic form. All study teeth remain caries-free and all fillings are intact. All restorations in both groups were present at the recall. All study teeth are vital and sound. No tooth exhibits post-operative discomfort. The patient satisfaction is in each group 100%.

Conclusion
iBOND Total Etch in combination with Venus Diamond reveals after 6 months an excellent clinical behaviour as the control group.

Biocompatibility

General
Biocompatibility is defined as the "ability of a material to perform with an appropriate host response when applied as intended"[27]. In accordance with the Medical Device Directive 93/42/EWG and national European medical device legislation, any medical device has to be evaluated by the legal medical device manufacturer regarding its clinical performance and safety. This includes an evaluation of biocompatibility in accordance with ISO 10993 and ISO 7405.

Bisphenol A
Biphenol A (BPA) is commonly used in plastic materials such as polycarbonate bottles or in the coatings of cans. For this purpose the Canadian and European health authorities banned the use of Bisphenol A. Bisphenol A is however not used in dental products such as composites. This is confirmed by the American Dental Association (ADA): http://ada.org/news/4728.aspx.

Composite materials contain monomeric substances that partly comprise of Bisphenol A in a tightly bound ether form.

The ADA states that there is no cause for concern at this time regarding potential BPA exposure from composites or sealants. Bisphenol A as a contamination would be several orders of magnitude below the maximum accepted dose of 50 µg/kg body weight per day set by the US EPA.

Bisphenol A has a very weak estrogenic activity (factor 1000 weaker than natural female hormone estradiol)[28]. In humans Bisphenol A is rapidly first-pass metabolized to 99.9% to BPA-glucoronite which shows no estrogenic activities[29]. Bisphenol A as such is not even detected in traces in the incoming ingredients of composites or adhesives of Heraeus Kulzer. The limit of detection in the utilized highly sensitive analytical method is 1 ppm. An exposure of patients to Bisphenol A contaminations can thus be excluded.

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Notes:
All diagramms have been established by Heraeus Kulzer.
Project names NEUN (Venus Diamond) and NEFL (Venus Diamond Flow) have been replaced by the corresponding product names.
Heraeus, Venus and iBOND are registered trademarks of Heraeus Kulzer.

Contact in Germany
Heraeus GmbH
Division Dentistry
Grüner Weg 11
63450 Hanau
Tel.: ++49 (0) 6181 35 44 44
Fax: ++49 (0) 6181 35 34 61
info.dent@heraeus.com
www.heraeus-kulzer.com

Contact in the United Kingdom
Heraeus Kulzer Ltd.
Heraeus House, Albert Road
Northbrook Street, Newbury
Berkshire, RG14 1DL
Phone +44 (0) 1635 30500
Fax +44 (0) 1635 30606
E-mail: sales@kulzer.uk
www.heraeus-kulzer.com

Contact in Australia
Heraeus Kulzer Australia Pty. Ltd.
Locked Bag 750
Roseville NSW 2069
Phone +61 29 417 8411
Fax +61 29 417 5093
E-mail: sales@kulzer.com.au
www.kulzer.com.au