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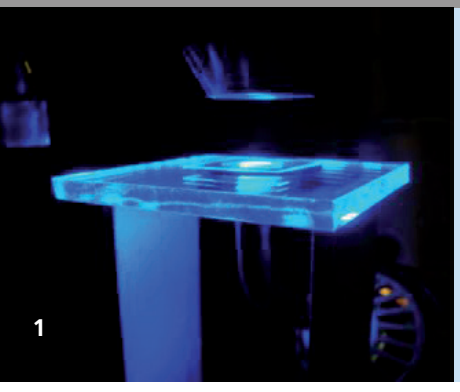
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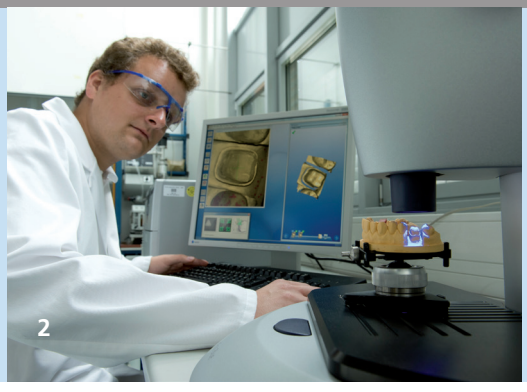
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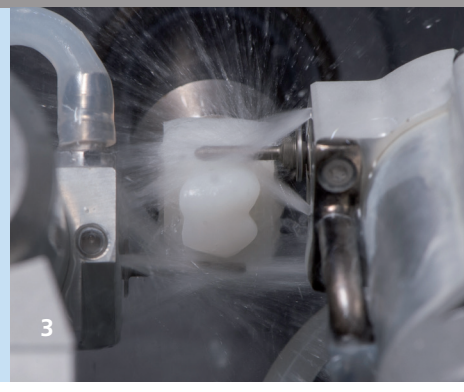
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1 *(In-situ) analysis of polymerization shrinkage*
2 *Up-to-date CAD/CAM technology*
3 *Milling of a fully anatomical crown*

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MATERIAL DEVELOPMENT FOR AFFORDABLE DENTISTRY

The importance of oral and dental health to an individual's quality of life is a major issue in the current health care debate. Tighter budgets on the part of health insurance funds and the soaring cost of dental treatment results into an enormous cost pressure, which leads to a demand for inexpensive, easy-to-apply but still high quality solutions for dental healthcare. With developments focused on various forms of dental treatment and methods of application, Fraunhofer ISC has extensive experience in this area.

ORMOCER®s – Diversity Thanks to Multifunctional Precursors

Dental filling materials based on inorganic-organic hybrid polymer composites (ORMOCER®s) have been on the market for many years (e.g. CeramX®, Dentsply; Admira®, VOCO) and are constantly being improved. With its profound research activities the Fraunhofer ISC is able to provide a wealth of experience and expertise in this field and can offer appropriate solutions. The main focus of current research is in the development of functionalized materials for dental conservation, as well as for dental prostheses. Core competencies include the synthesis and development of multifunctional precursors through to materials. The material properties of inorganic-organic hybrid polymers from the material class of ORMOCER®s can be controlled easily and very precise. They are able to cover a large viscosity and a wide Young`s modulus range. Furthermore, they possess a low polymerization shrinkage compared to conventional monomer-based systems (see table 1 for complete property profile). In combination with functionalized nanoparticles, high-quality, biocompatible (nano-) hybrid composite restoration materials with extremely low polymerization shrinkage and very high flexural strengths are achieved. Further more, the material can be tailored to any specific application such as monomer-free resin systems, (nano-) hybrid composites or glass ionomer cements. That provides

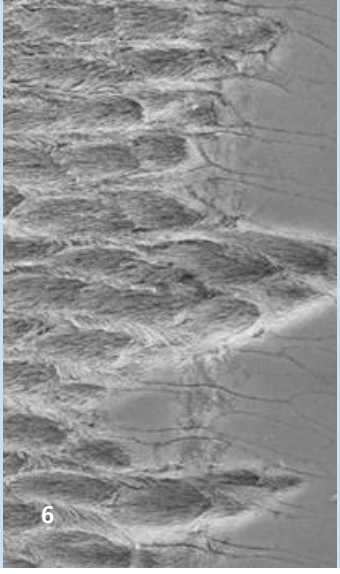

Table 1: Property profiles

	Matrix system	Composite | GIZ
Viscosity	0.1 – 1000 Pa·s	adjustable
Filler content	—	≤ 87 wt.-% (75 vol.-%)
Polymerization shrinkage	2 – 8 vol.-%	adjustable (≥ 1.3 vol.-%)
Young´s modulus	1 – 4000 MPa	≤ 17 GPa
Flexural strength	≤ 130 MPa	≤ 180 MPa
Compressive strength	≤ 300 MPa	≤ 500 MPa
Coefficient of expansion	50 – 250·10-6 K-1 (5 – 50°C)	≥ 17·10-6 K-1
Elastic elongation	≤ 130% (special matrix)	—
Radiopacity	—	310 – 360% Al

an excellent basis for direct and indirect restoration such as fillings, core build-ups, sealants or crowns, inlays, onlays and prosthetics. Moreover, different processes concerning structuring of materials, filler synthesis and filler incorporations are being provided. Therefore, ORMOCER®s offer an excellent basis for property profiles adapted to customer-specific requirements.
As part of these development projects a wide variety of manufacturing and processing techniques are available:

- Silane/resin/matrix synthesis incl. scale-up: Reactors up to 60 l of volumetric capacity
- (Nano-) Particle synthesis and functionalization: Spray drying, precipitation and emulsion techniques
- Filler incorporation/composite manufacturing: SpeedMixer™, three roll mill, planetary mixer
- Application adapted hardening techniques: Photo-, thermal-, redox-induced polymerization
- Processing technology: Up-to-date dental CAD/CAM-based milling unit

Novel Concept of Dental Treatment – Chairside Crowns

High-quality but affordable materials for crowns through an optimized ORMOCER® material basis will be provided. With this new concept, intraoral digital impression, the production of a high quality esthetic crown as well as the insertion will be chairside, i.e. just in one session without the need of dental technicians. In contrast to conventional ceramic crowns the chairside technique will minimize the workload and the stress for the patient as well as reducing the treatment costs significantly.

All-in-One Adhesives – Easy-to-Apply Material Solutions

The adhesive technology represents another essential field of research. Polymerizable organic compounds containing acidic groups are important to achieve required properties, such as optimal wetting, sufficient etching behavior, complexation and thus the adhesive effect on biological interfaces (e.g. tooth substance). Today self-etching dental adhesives often still have some significant shortcomings such as fission products due to susceptibility to hydrolysis, residual non-crosslinked monomers or insufficient etching of the tooth substance. Newly developed adhesive systems based on monomerfree ORMOCER®s functionalized with different kinds and numbers of acidic groups (e.g. carbonic, phosphoric, phosphonic, sulfonic, etc.) provide an improved etching behavior while simplifying the product application.

Application and Customer Specific Chemical and Physical Characterization

These developments in material research are accompanied by a broad variety of extensive and specialized characterization methods. Our techniques are being continually modified to take account of new insights and customer specifications. Furthermore, we accept orders for individual characterization of customer-specific materials.

Our scope of high quality service in terms of analytical methods includes:

- Analysis of rheology/flow behavior
- Chemical analysis: Multicore NMR, IR, (µ-) RAMAN, XRD, ICP, GC, etc.
- Analysis of curing process: (µ-) RAMAN, (photo) DSC, IR, in-situ polymerization temperature measurements
- (In-situ) polymerization shrinkage: Laser/buoyancy method
- Material analysis (Fracture toughness, compressive/tensile strength, elasticity modulus, elongation, coefficient of thermal expansion): DMA, universal testing machine, Dilatometer
- Surface analysis and mechanics: ACTA abrasion, chewing simulator, Vickers hardness, SEM, TEM, AFM, laser scanning microscopy
- Interfacial analysis and mechanics regarding tooth tissue/model systems: (Micro-) tensile test, shear test
- Etching and wetting behavior: (µ-) RAMAN, contact angle measurements
- Water absorption/solubility: Gravimetric measurements
- Esthetics: Color/translucency/scattered light measurements
- Filler/Particle characterization: DLS, Fraunhofer diffraction, SEM, TEM
- Close collaboration with our Center for Applied Analytics (accredited test laboratory certified to DIN EN ISO/IEC 17025, equipped with an extensive range of cutting-edge scientific instruments and analysis systems)

4 *Highly translucent crown*
5 *Section through multi-layer crown*
6 *SEM image: Partially etched enamel surface*