
Ceramic Thin Films by Sol-Gel Processing and Laser Sintering

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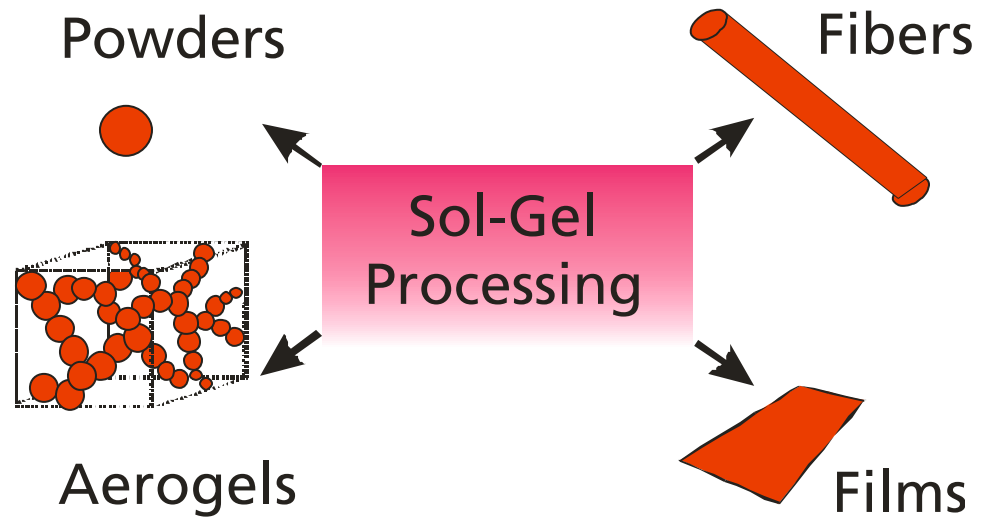
Fraunhofer Institut
Silicatforschung

Sol-Gel Processing

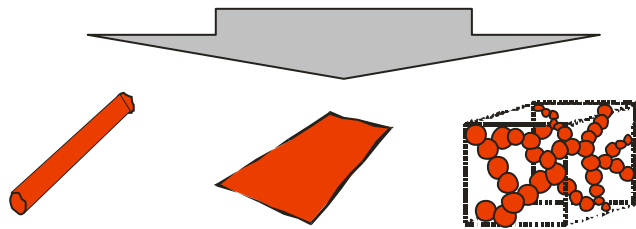
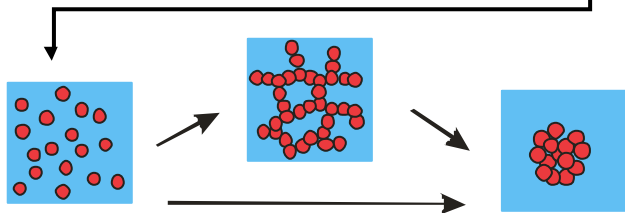
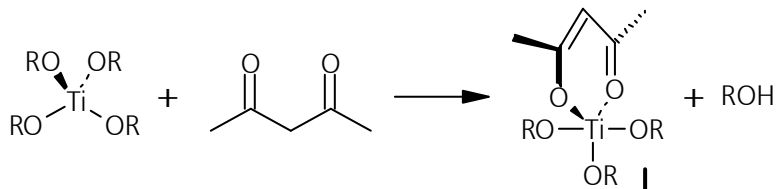
„Preparation of non-metallic inorganic materials from chemical precursors“

Advantages:

- low processing temperatures
- wide range of compositions
- adaptability of microstructures



Sol-Gel Processing: Basic Reactions



Ceramic Product

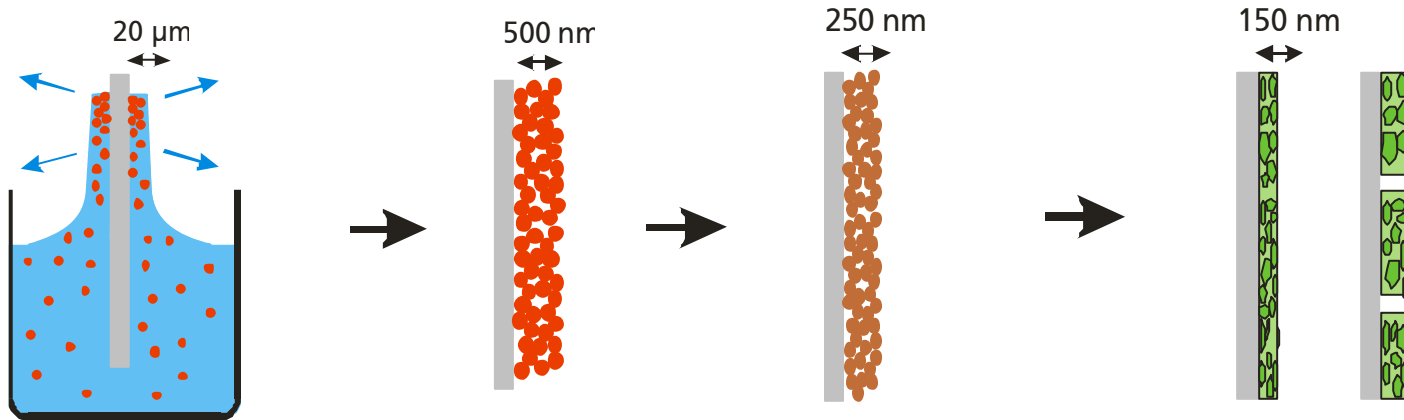
Molecular Scale:
Complexation and Hydrolysis

Nanoscale:
Particle formation and
aggregation

Mesoscopic/Macroscopic Scale:
Shaping

Densification / Crystallization

Sol-Gel Thin Films: Steps of Film Formation



Dip Coating:

Accumulation of particles in liquid layer

Drying:

Evaporation of solvent and volatile products

Pyrolysis:

removal of covalently bond organics

Sintering:

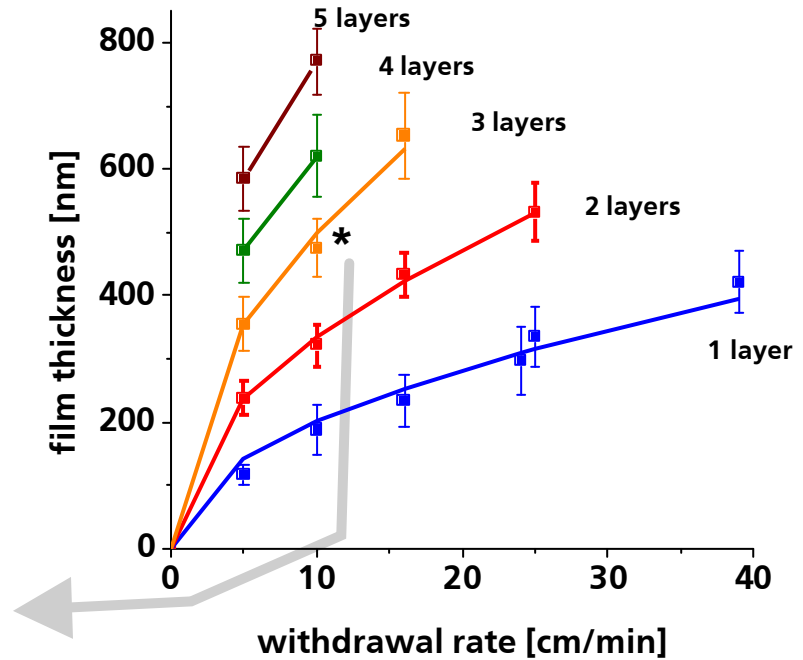
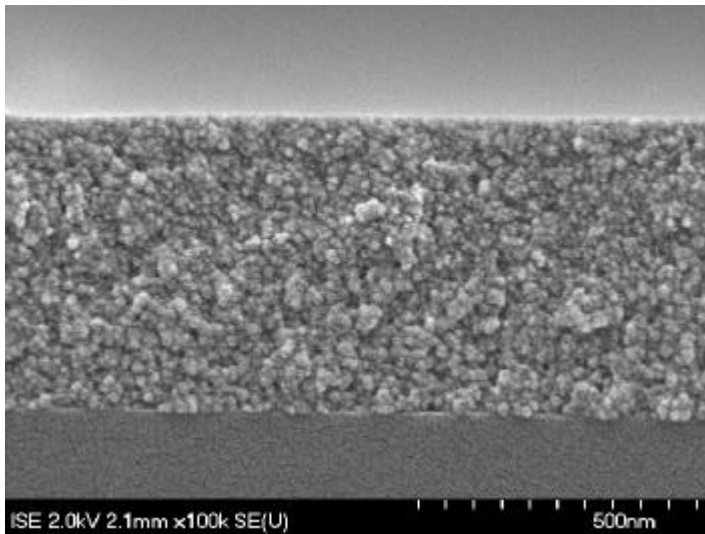
crystallization, final densification

Hydrolysis and condensation

Structural changes / densification

Sol-Gel Thin Films: Film Thickness

Increase of film thickness and quality by optimization of processing parameters.

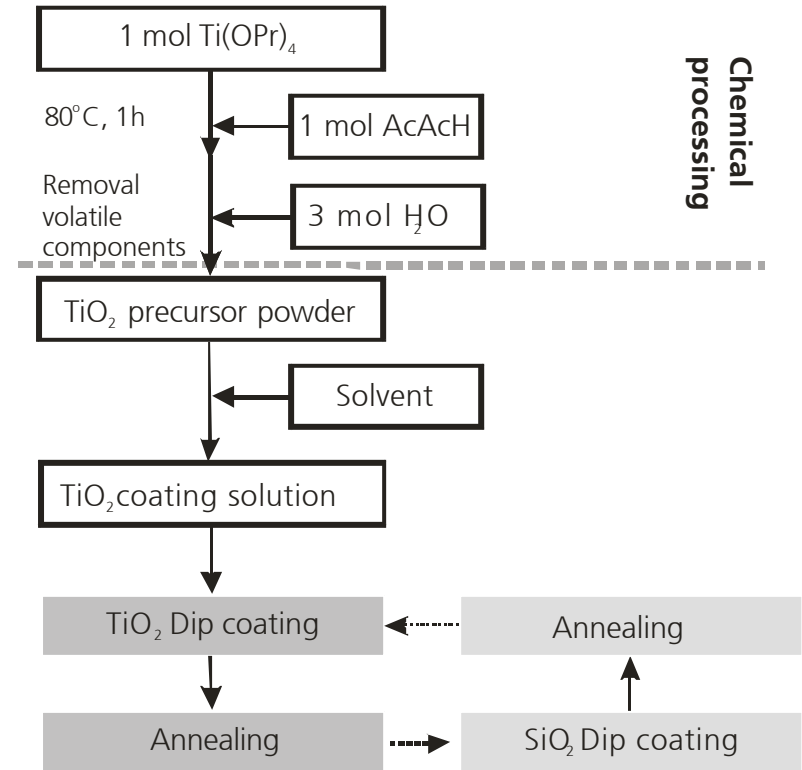


Sol-Gel Thin Films: Stability of Sols

Industrial processing of sol-gel films often limited by sol stability

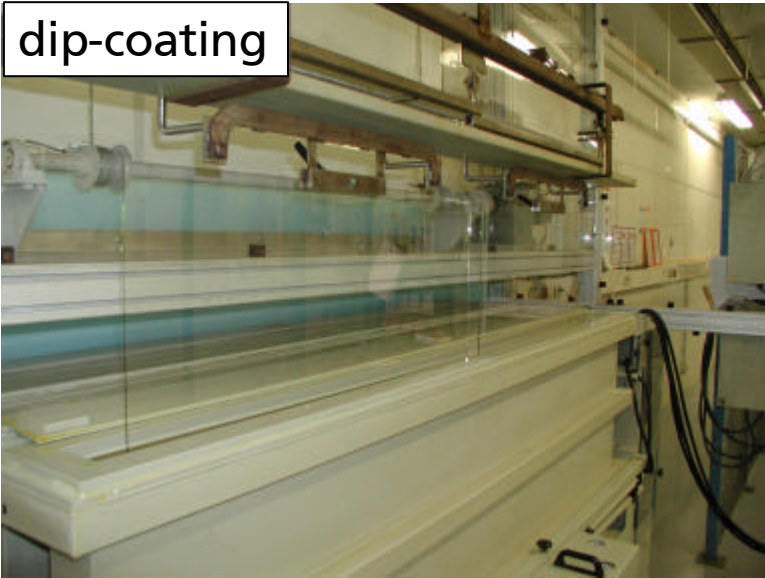
→ Soluble precursor powders

- ☐ amorphous
- ☐ long-term stable at production site



P.Löbmann, P.Röhlen "Industrial Processing of TiO_2 Thin Films from Soluble Precursor Powders" *J.GlassSci.Tec.* **76** (2003) 1.

dip-coating



pre-drying



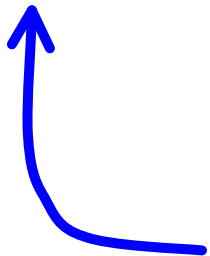
collection



thermal treatment



characterization



Unique structures by sol-gel processing

dense film



Sol-gel processing,
CVD, PVD, plasma spraying ...

porous film



Sol-gel processing:

porous antireflection coating

microstructured
film



microstructured surfaces

→ antireflection

→ modified wetting / self-cleaning

Porous antireflection coatings

Large area coating 200*100 cm²
for covering of both
solar cells and collectors

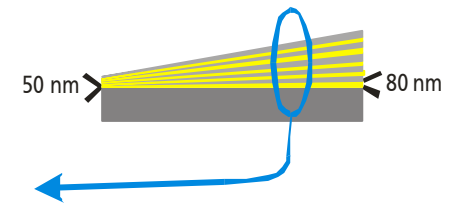
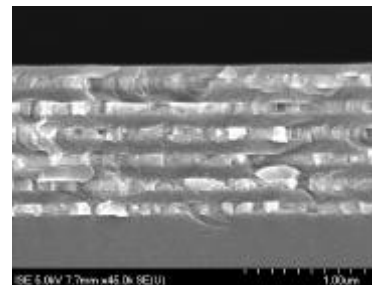
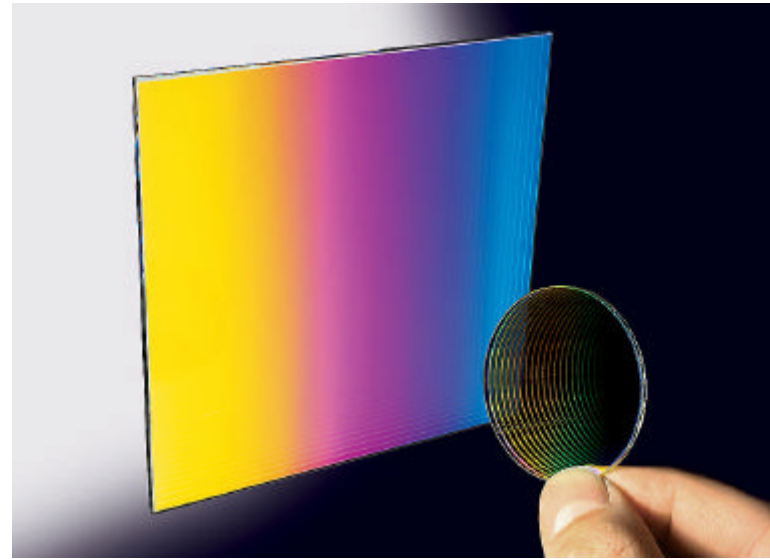


Sol-Gel Thin Films: Multilayer Assemblies

Optical interference filters by alternate TiO_2 - SiO_2 coatings.

Increase of withdrawal rate during dip-coating process

- increase of film thickness
- change of optical properties
- color effect filter VARIOTRANS®

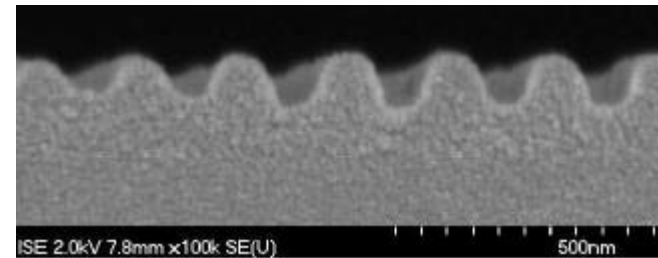
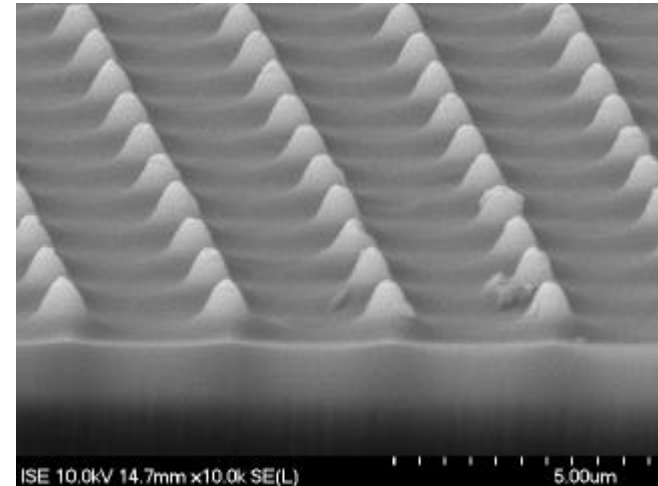


Sol-Gel Thin Films: Microstructured Surfaces

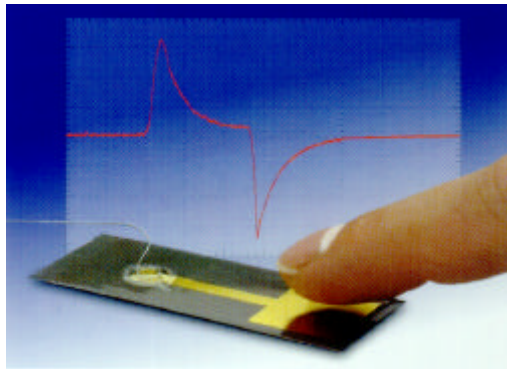
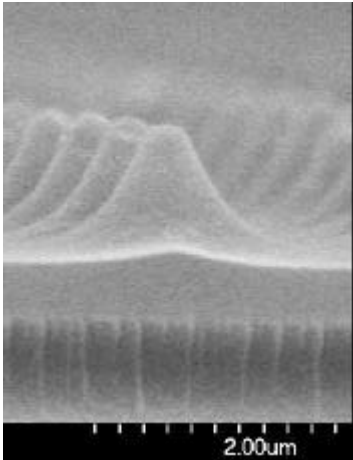
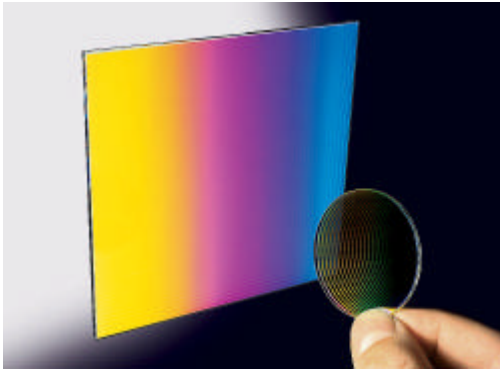
Embossing of sol-gel films with polymer stampers

„Material bionics“:

- ❑ modified wetting by „Lotus“-structures →
- ❑ antireflection coatings by „Moths' eyes“ structures” ↘



Summary: Ceramic Sol-Gel Films



- various compositions (SiO_2 , TiO_2 , ZrO_2 , PZT, ...)
- hybrid organic/inorganic materials (ORMOCERs®)
- large area coatings with high qualities at moderate costs
- microstructuring by...
 - withdrawal rate
 - specific introduction of porosity
 - embossing techniques
- densification and crystallization by thermal treatment or laser sintering