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Tuning the crystallization temperature of titanium dioxide thin films by incorporating silicon dioxide via supercycle atomic layer deposition

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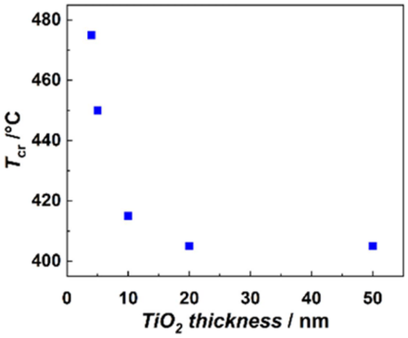
The crystal phase of titania (TiO_2) – amorphous, anatase or rutile – directly influences its structural, thermal, mechanical, electrical and optical properties. Optimizing the properties of nanoscale TiO_2 thin films for electronic, photocatalytic and sensing applications requires controlling the film crystallinity. Heat treatment (annealing) after atomic layer deposition (ALD) represents one approach to crystalizing the as-deposited thin amorphous TiO_2 films. Additionally, the introduction of dopants or multilayers into the TiO_2 films with various materials impacts the crystallization behavior of TiO_2.

Silica (SiO_2) ceramics possess a low refractive index and similar high chemical and mechanical stability to TiO_2. Earlier studies of annealed TiO_2-SiO_2 multilayers found that the temperature that TiO_2 crystallizes at depends on the thickness of the layers of TiO_2 – SiO_2. Surface and interface energies exert greater influence on thinner films, which becomes more significant as the surface area-to-volume ratio increases.

A new study by Hedrich et al.[1] monitors the crystallization of mixed TiO_2 and SiO_2 films. The study compares multilayers and doped TiO_2-SiO_2 materials prepared by ALD in Arradiance's GEMStar^{TM} system. As expected, the phase transition temperature of TiO_2 in multilayers (380°C – 475°C) increased with increasing amount of SiO_2 and decreasing TiO_2 thickness. SiO_2 remained amorphous throughout all anneals. The study also showed that adding SiO_2 can adjust optical properties such as the refractive index. Using ALD to create these precise multilayers or doped films makes it possible to coat a wide range of highly porous structures or 3D shaped surfaces, which is not possible with other coating techniques.



Arradiance enables thin-film semiconductor, photocatalysis, sensing and advanced energy state-of-the-art ALD solutions. For more information on GEMStar^{TM} Technology, ALD Systems or Foundry Services, please contact Arradiance.

[1] *Carina Hedrich et.al., "Tuning the crystallization temperature of titanium dioxide thin films by incorporating silicon dioxide via supercycle atomic layer deposition", Surfaces and Interfaces 57 (2025) 105696*
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