Patentix Achieves Breakthrough in Deposition of Rutile-GeO_2 Thin Film on Silicon Substrate

～A step toward the cost-effective production of r-GeO_2 power semiconductors.～

Patentix Inc. announced its success in depositing rutile-type germanium dioxide (r-GeO_2) thin film on a standard silicon (Si) substrate. This breakthrough establishes the foundation for reducing the manufacturing cost of r-GeO_2 wafers, a highly anticipated material for next-generation power semiconductors.

Background

While silicon (Si), with its 1.12 eV bandgap, has long been the cornerstone of the power semiconductor industry due to its low cost and high quality, its performance is approaching fundamental physical limits. This has spurred a market transition toward wide-bandgap semiconductors like silicon carbide (SiC, 3.3 eV) and gallium nitride (GaN, 3.4 eV).

More recently, rutile-type germanium dioxide (r-GeO_2) has emerged as a highly promising candidate for the next frontier in power electronics. With an ultra-wide bandgap of 4.68 eV and theoretical potential for both p-type and n-type conductivity, r-GeO_2 is poised to outperform both SiC and GaN.

Leveraging its proprietary Phantom SVD method, Patentix has demonstrated deposition of r-GeO_2 crystalline films on various substrates, including TiO_2 and SiC [1, 2]. However, achieving widespread adoption of new semiconductor materials including r-GeO_2, requires overcoming the high-cost problem of their substrates. Even SiC, despite recent cost reduction trends, remains expensive compared to Si due to its slow, energy-intensive sublimation growth process. The GaN industry has mitigated this problem by developing GaN-on-Si technology, where the GaN layer is grown heteroepitaxially on a low-cost Si wafer. A similar approach seemed promising for r-GeO_2 as well, but deposition of crystalline r-GeO_2 thin films on Si substrates has never been successfully demonstrated.

The Achievement

In a world-first achievement, Patentix has successfully deposited a crystalline r-GeO_2 film on a Si(100) substrate with a conductive buffer layer. (Figure 1)

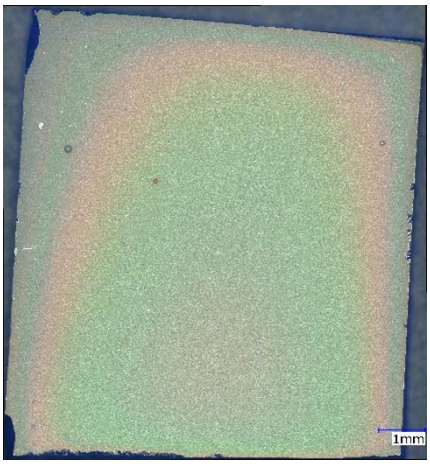

Figure 1. Photograph of an r-GeO_2 thin film deposited on a conductive buffer layer on a Si(100) substrate.

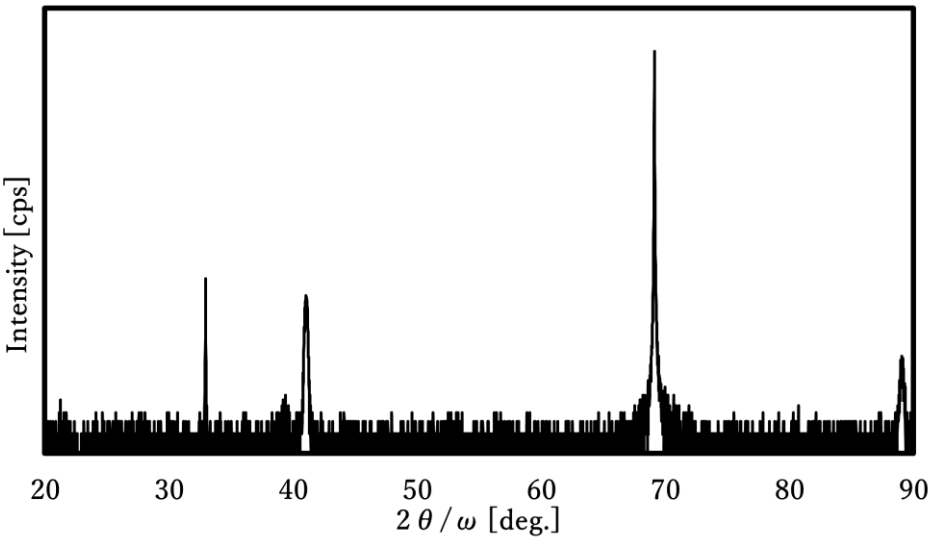

Figure 2. XRD profile of a GeO_2/Si sample. (*Note: The Si(200) reflection, though a forbidden reflection, is observed.)

Analysis of the GeO_2-on-Si sample via X-ray diffraction (XRD) reveals a distinct peak corresponding to the r-GeO_2 phase (Figure 2). The conductive buffer layer, which enables crystalline r-GeO_2 thin film deposition on Si substates, is a key innovation, directly enabling the fabrication of vertical power devices, the dominant architecture in the industry.

This breakthrough confirms the viability of GeO_2-on-Si substrates and signals a paradigm

shift: the potential to manufacture next-generation r-GeO_2 power semiconductors, which promise superior performance to SiC, at a more competitive cost.

Future Outlook

Building on this success, Patentix will intensify its R&D efforts to further enhance the quality and scalability of r-GeO_2 thin films, accelerating the commercialization of large-diameter GeO_2-on-Si wafers.

Concurrently, we will advance the development and characterization of prototype power devices built on this new platform.

References [1] Y. Shimizu, et al., “N-Type Cnductivity in Single-Phase r-GeO_2 Thin Films,” 2024 MRS Fall Meeting & Exhibit, SF04.15.08 (2024).
[2] F. Yagura et al., "Crystal growth of r-GeO_2 thin film on 4H-SiC substrate using buffer layer," The 86th JSAP Autumn Meeting, 2025, 7a-N322-9 (submitted)