



# Investigation of color centers in silicon carbide for quantum technology applications

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## Abstract

Silicon carbide (SiC) possesses excellent properties and has seen advances in crystal growth, microfabrication, and processing technologies, making it a promising material for scalable quantum devices. The author investigates SiC color centers for quantum applications, focusing on those localized at the insulator/SiC interface. These interface color centers exhibit extremely bright photoluminescence at room temperature, yet their fundamental properties remain poorly understood. This study presents detailed optical and electrical evaluations, leading to the successful identification of their energy levels — an essential step toward controlling and utilizing these centers for quantum technologies.

## Background & Results

Color centers originating from point defects in semiconductors can function as single-photon emitters, making them promising for quantum technologies, e.g. quantum computing and quantum cryptography. Silicon carbide (SiC), a wide bandgap semiconductor with excellent material properties, has gained attention as a scalable platform for quantum devices due to advances in crystal growth, microfabrication, and processing technologies.

While most color center studies focus on bulk defects, SiC is known to host highly bright color centers at the interface with insulating films (Fig. 1). Unlike conventional centers formed via costly ion implantation, these interface centers can be easily created

through thermal oxidation. However, their properties and emission mechanisms have remained unclear.

This study systematically varied oxidation conditions to induce interface color centers and investigated correlations between their optical and electrical characteristics. The results revealed a strong association between the color centers and specific electrical defects, and identified distinct energy levels ranging from 0.65 to 0.92 eV below the conduction band (Fig. 2). A comparison with previous theoretical studies suggests that di-carbon antisite defects ((C<sub>2</sub>)<sub>Si</sub>) near the interface are likely candidates for the origin of the color centers. These findings significantly advance the understanding of interface color centers and provide the foundation for their controlled engineering.

## Significance of the research and Future perspective

This study provides crucial insight into the origin of interface color centers, paving the way for their controllability and marking a significant step toward practical quantum technologies. The insulator/semiconductor interface is a core component of modern semiconductor devices, such as transistors in CPUs. Due to their compatibility with established semiconductor fabrication processes, interface color centers offer promising scalability and integrability. Based on the fundamental understanding established here, further control of these centers could enable on-chip implementation and integration of quantum functions, bridging conventional semiconductor technology with emerging quantum applications.

Manufacturing technologies

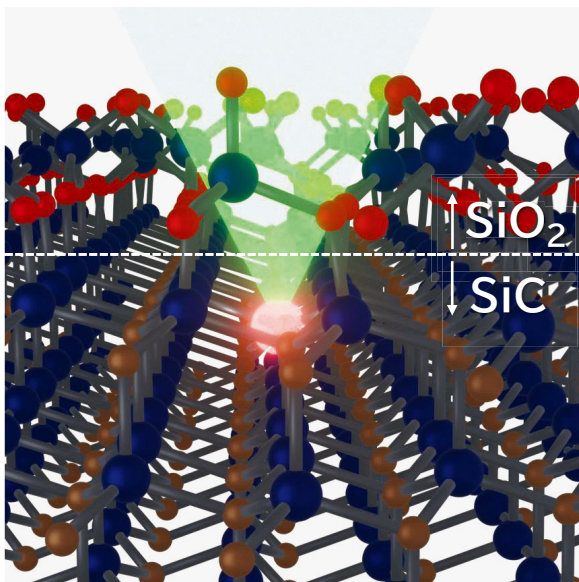


Fig. 1: Schematic diagram of color centers at the insulator/SiC interface

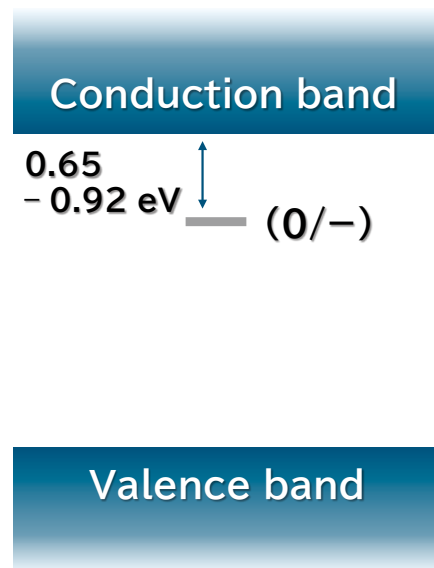


Fig. 2: Detected energy level of the interface color centers

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widegap semiconductors, silicon carbide, point defects, color centers