



## Next-Generation Electronics: Realizing 2-D Hole Gas in Oxide Materials

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**The Wisconsin Alumni Research Foundation (WARF) is seeking commercial partners interested in developing the first known method for creating 2-D hole gas and 2-D electron gas in the same oxide system. This technology has powerful applications in the emerging field of oxide electronics materials.**

### Overview

The discovery of two-dimensionally confined charge carriers has opened an exciting field of new research and various device applications. In particular, two-dimensional electron gas (2DEG) is used in electronic devices and has been extensively studied due to its exotic physical properties at polar/non-polar oxide interfaces.

Its counterpart, two-dimensional hole gas (2DHG), has huge potential but has not been clearly observed despite a decade of effort. Furthermore, the coexistence of 2DEG and 2DHG within the same oxide structure has not been achieved. The ability to create and manipulate both gasses in the same system would create new opportunities in functional electronics and more.

### The Invention

UW-Madison researchers have developed the first known method for realizing 2DHG in an oxide material, and for achieving both 2DHG and 2DEG in the same system.

The researchers designed an oxide heterostructure with alternating layers of strontium oxide and titanium dioxide as the base, a polar layer of lanthanum oxide and aluminum oxide, followed by a non-polar layer of strontium oxide and titanium dioxide on the top. The hole gas forms at the interface of the layers on the top, while the electron gas forms at the interface of the layers on the bottom. Both gas layers are thin with highly mobile and concentrated electrons/holes, respectively.

### Applications

- The realization of 2DHG in oxides could lead to the development of new, low-dimensional electronics.
- Transistors/field effect transistors, optoelectronics/light harvesting devices

### Key Benefits

- High electron/hole mobility, respectively
- High quality and atomically well-defined interfaces
- Provides a platform for the exciting physics of confined electron-hole bilayer systems

### Stage of Development

The researchers are the first to demonstrate highly mobile 2DHG in epitaxially grown SrTiO<sub>3</sub>/LaAlO<sub>3</sub>/SrTiO<sub>3</sub> heterostructures, and the coexistence of 2DHG and 2DEG in the same oxide system. Electrical transport measurements showed that the top interface is highly conductive, as is the bottom interface. The sheet carrier density of the 2DHG was shown to be two orders of magnitude higher than existing, gallium arsenide (GaAs)-based systems.

## Additional Information

### For More Information About the Inventors

- [Chang-Beom Eom](#)

### Related Technologies

- [Find more thin-film innovations developed by Prof. Chang-Beom Eom](#)

### Publications

- Lee H. et al. 2018. Direct Observation of a Two-Dimensional Hole Gas at Oxide Interfaces. Nature Materials 17 (3), 231-236.
- [Read a news story about this technology.](#)

### Tech Fields

- [Semiconductors & Integrated Circuits : Components & materials](#)

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