High Mobility Thin Film Semiconductors for Photovoltaics and Flexible Electronics

Research Themes

Achieving high performance characteristics, mechanical flexibility, and cost-effective manufacturing in photovoltaics and flexible electronics is highly desired but a very challenging task. Traditional single-crystalline semiconductor wafers delivers the highest performance in the devices, but the materials and fabrication process are expensive and the wafers lack mechanical flexibility. Alternative substitutions are amorphous or polycrystalline semiconductor thin-film materials, however, they exhibit poor performance due to low-mobility and non-uniformity caused by the grain size and grain boundaries in semiconductor thin films. Therefore, we developed an approach, "Seed and Epitaxy", to fabricate high mobility thin film semiconductors (Si, Ge, GaAs, etc.) on flexible foreign substrates (flexible glass, metal tape, etc.) via roll-to-roll processing to achieve both low cost and high performance. The resulting thin film transistor (TFT) devices fabricated by flexible Si and Ge thin films exhibit exceptional performance, which open a new avenue to realize low-cost, large area, high-performance flexible electronics and optoelectronics.

Recent Accomplishments

- Achieved high-performance flexible TFTs based on single-crystal-like Ge on glass. It exhibits performance characteristics with on/off ratio of ~106, a field-effect mobility of ~105 cm2/V.s, and saturation current levels of ~3.5 mA, which are significantly higher than performance metrics of other state-of-the-art TFTs based on amorphous Si, organic semiconductors, and semiconducting oxides. This paper was selected as a frontispiece article in August 2016 issue of Advanced Electronic Materials.

- Demonstrated exceptional-performance flexible TFTs using single-crystal-like Si thin film on metal substrates. It showed a field-effect mobility of ~200 cm2/V-s, which is orders-of-magnitude higher than the device characteristics of conventional flexible TFTs. The realization of flexible and high-performance Si TFTs can establish a new pathway for extended applications of flexible electronics such as amplification and digital circuits, more than currently-dominant display switches. The result was published in ACS Applied Materials and Interface, Oct., 2016.

Issues

- Defect density reduction for both single-crystal-like Si and Ge thin films
- Alternative conductive buffer layers study for epitaxial Si and Ge growth
- Printed TFTs on nearly-single-crystalline Si and Ge thin films by roll-to-roll processing

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