**High aspect ratio β-Ga2O3 nanostructures: MacEtch, Passivation, and Devices**

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**Motivation** β-Ga2O3, with an ultra-wide bandgap (UWB) of ~ 4.6 – 4.9 eV and bulk substrate availability, has drawn enormous interests in the power electronics and solar-blind optoelectronics community. Fabricating high-aspect-ratio β-Ga2O3 3D nanostructures without surface damage is essential for next-generation high power and high speed devices. However, dry etch typically damages the surface due to the high-energy ions, while most wet etching techniques can only produce very limited aspect ratios.

**Methods** Metal-assisted chemical etch (MacEtch) is an unorthodox anisotropic wet etching method, that defies the isotropic nature of wet etch through local catalysis effect and enables site-controlled semiconductor nanostructure fabrication with unpresented aspect ratio (e.g. > 200:1 for Si) and versatility. Since it was first developed for open-circuit porous silicon formation [1], catalyst-site-specific MacEtch has enabled the formation of nanostructures of a broad range of semiconductors, including silicon, germanium, III-As, III-P, III-N, SiC, and oxides, as well as some of their heterostructures. The versatility of MacEtch is also evident in the unique characteristics of different types of MacEtch. Inverse-MacEtch (i-MacEtch) allows the formation of atomically smooth sidewalls; magnetic-field guided MacEtch (h-MacEtch) enables 3D control of the etching trajectory; Self-Anchored Catalyst MacEtch (SAC-MacEtch) promotes the sidewall verticality for large via by using porous catalyst; UV-assisted MacEtch (UV-MacEtch) makes plasma-free wide-bandgap semiconductor etch possible; and the ultimate vapor phase MacEtch (VP-MacEtch), while maintaining the damage-free nature, truly takes the technology towards scalability and manufacturability, including the successful demonstration of CMOS compatible titanium nitride (TiN) catalyzed etch. The simplicity, versatility, manufacturability, and realistic potential of MacEtch make it well-positioned to enhance or replace dry etch methods for future generation of 3D transistors, through-silicon-vias, trench memory, thermoelectric, detectors, and photovoltaic devices.

**Results** In this talk, β-Ga2O3 nanofin arrays by inverse metal-assisted chemical etching (MacEtch), under UV light irradiation, with a high aspect ratio and excellent surfaces quality are presented. The strongly crystal-orientation-dependent etching behaviours are found and three kinds of vertical structures are formed after the MacEtch process. The Schottky barrier heights (SBHs) between platinum (Pt) and different MacEtch-formed β-Ga2O3 surfaces and sidewalls are found to decrease as the aspect ratio of the β-Ga2O3 structure increases. This is attributed to the varying oxygen composition on the surface after MacEtch, as shown by the XPS and TEM examination. Very little hysteresis has been observed in the capacitance-voltage characteristics of the 3D Pt/ Al2O3/ β-Ga2O3 MOS capacitor structures, and the lowest interface trap density extracted from etched interfaces is only 2.73×1011 cm-2-eV-1, which is comparable to those of other published values of unetched β-Ga2O3surfaces. Epitaxial regrowth of (AlGa)2O3 on the MacEtch-produced 3D β-Ga2O3 nanostructures will also be discussed.

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**References**

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