Nanoheteroepitaxy for Photovoltaic Devices on Non-crystalline Substrates

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Key constraints in growing planar epitaxial thin film of a semiconductor on another single crystal substrate are lattice and thermal expansion coefficient mismatches, material incompatibilities and differences in crystal structure [1]. These limitations can be circumvented by growing semiconductor nanowire (NW) heterostructures that can even accommodate large mismatch due to their small dimensions. Recently, a number of highly crystalline III-V NWs were grown on matching and mismatched wafers with lattice mismatch as high as 8.1% [2-4]. The ability to grow dissimilar materials with large mismatches on one substrate removes the integration related constraints of incorporating photonics with electronics, and therefore an associated challenge of on-chip electronic-to-optical (E/O) and optical-to-electronic (O/E) conversions for information processing using primarily electrons and the majority of the information transfer using photons. Semiconductor NWs with direct bandgap and high absorption coefficients can offer high efficiency in solar cells.

We recently reported the epitaxial growth of highly aligned InP NWs on Si substrates [2]. In addition, we bridged InP NWs between two vertical, (111)-oriented Si surfaces by forming connections during the NW growth facilitating their direct electrical probing via Si electrodes for applications in nano-electronic and photonic devices (Fig. 1a-b). More recently, we introduced a new method of synthesizing III-V NWs on a *non-single crystalline surface* that directly relaxes any lattice matching conditions and demonstrated a device for high-speed photodetection based on InP NWs grown in the form of nano-bridges between prefabricated electrodes of hydrogenated microcrystalline silicon (μc-Si:H) as shown in Fig. 1c-f [5]. The devices was fabricated on an amorphous glass surface and offer opportunities for designing low-cost highly efficient solar cells on non-single crystal surfaces.

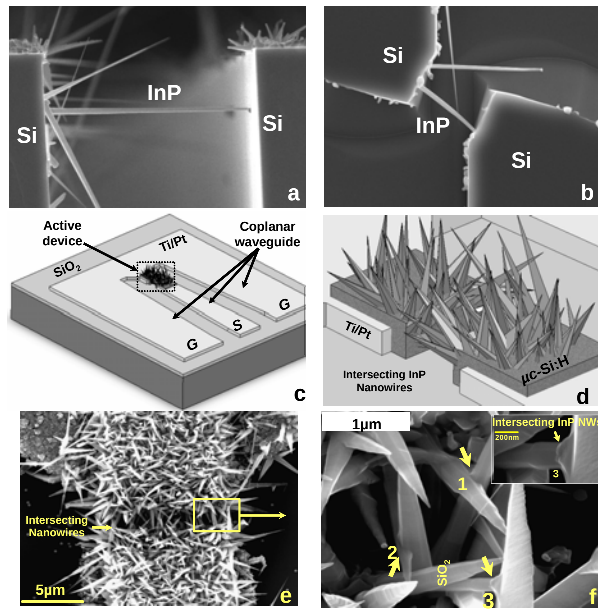

Figure 1: (a) Cross-sectional SEM images of lateral epitaxial growth of InP nanowires across a 4μm-wide trench and connecting to an opposite sidewall. (b) Top view of Figure 1-a [2]. (c) Illustration of a nanowire based photoconductive device, (d) A close-up view of the intersecting nanowire photoconductors, (e-f) Zoomed-in views of some welded (bridged) nanowires indicated by arrows. The bridged gap is 2μm. The bridges establish a electrical continuity over the gap between the two *n*-Si:H segments. The random orientation of the NWs is caused by the lack of crystallographic translational symmetry on the surface of the *n*-Si:H film. NWs grew only on the *n*-Si:H segments suggesting a precondition of definite short-range atomic ordering for a coherent growth of nanowire heterostructures.

References:

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