Fabrication Techniques for Unusual Electronic Systems: Silicon Microstructures for Photovoltaic Modules

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Electronics that can cover large areas, often referred to as macroelectronics, has received increasing attention over the past decade mainly due to it use in display systems, but increasingly due to certain forms of macroelectronics that can be integrated with thin plastic sheets or elastomeric substrates to yield mechanically flexible and stretchable electronic systems.[1]

Macroelectronic applications such as foldable and portable displays, sensory skins, and flexible photovoltaic (PV) modules represent areas in which this technology can be applied. Progress in the area of macroelectronics is measured by the overall size of these systems and their mechanical properties (e.g. bendability or stretchability) rather than by the feature sizes of individual circuit components, as is the case in microelectronics. The main hurdle with macroelectronics is designing approaches or materials that can be assembled onto plastic or other substrates while maintaining their high performance. Individual microstructured inorganic materials (e.g., μ-silicon, μ-GaAs etc) in the forms of wires, sheets, bars or platelets (see figure 1) which can be assembled by elastomeric stamps onto various substrates are of particular interest and represent a possible routes for achieving macroelectronic systems.[2-4]

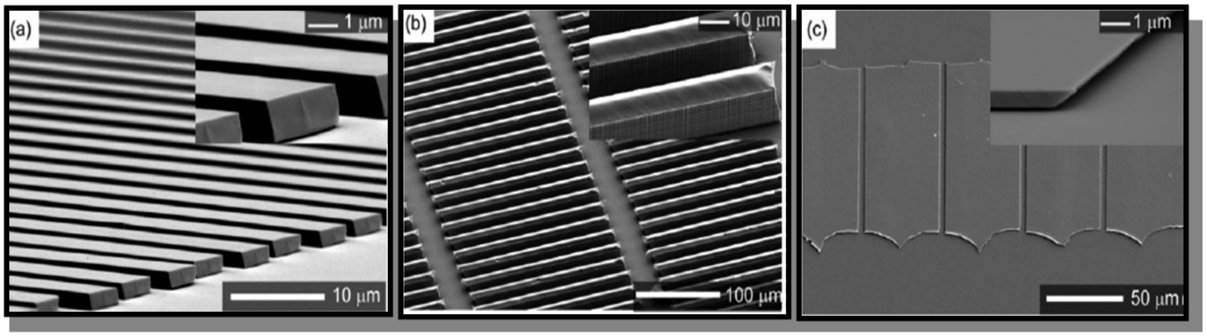

Figure 1. Microstructured Silicon form factors (a) ribbons (b) bars and (c) sheets

This seminar will describe three topics of my dissertation research: i) First, a new type, low-cost and versatile microstructured silicon form factor which is fabricated via top-down approaches. These form factors can be used as active films in high performance thin-film transistors and unconventional silicon photovoltaic modules. The first form factors reported are silicon nanoribbons with submicron spatial dimensions for macroelectronic circuits.[5, 6] Although, devices built with these non-optimized nanoribbons show good electrical properties and performance, their intrinsic properties lead to unwanted defects which limit there application possibilities ii) Second, a more optimized silicon form factor consist of a silicon microbar which can be used as active absorbers for the fabrication of micro photovoltaic devices is presented.[7] The as-fabricated microstructured materials can be used to produce high performance and bendable silicon transistors and photovoltaic modules composed of silicon microcells with reduced purity requirements, high voltage outputs and mechanically flexible designs.[8] These specific applications are a result of their microscale design combined with the ability to manipulate the material, in a practical way, by using elastomeric stamps (PDMS). The slabs of PDMS that are used for printing and assembling these semiconductor materials can also be used for fabricating templates for sensor applications. ii) Third, we demonstrate the use of elastomeric stamps for the fabrication of nanostructured substrates for use in surface enhanced raman scattering (SERS) as shown in figure 2.[9] Collectively, the results show that the use of PDMS stamps, inorganic materials, design layout and performance are suitable for developing unconventional high performance transistors, Si PV modules and sensors which cannot be achieved with conventional technologies

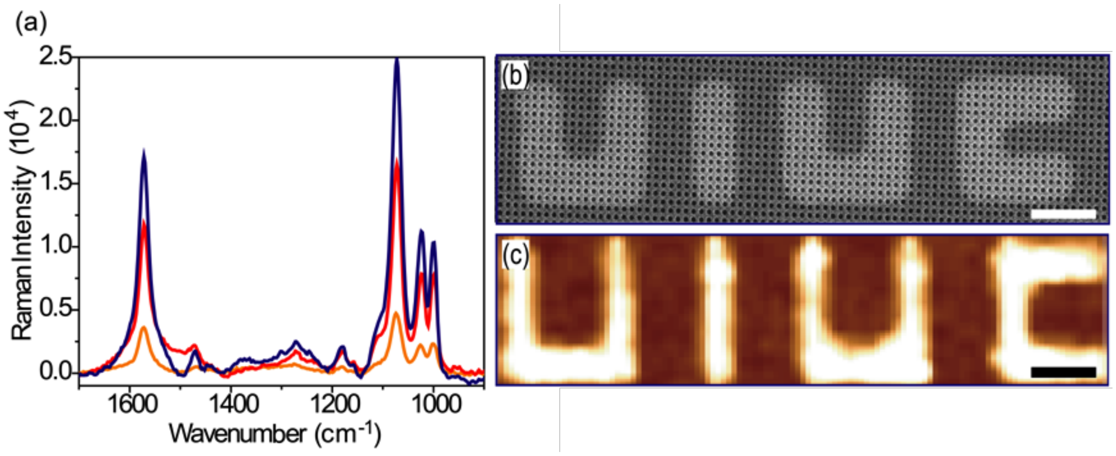

Figure 2. (a) SERS spectra of Benzenethiol (b) Scanning electron image of microcontact printed benzenethiol and the (c) corresponding Raman image. Scale bar is 10 µm.

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