Parylene/GaAs Nanowire Composites for Optoelectronics

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Abstract and Introduction:

Complementary metal oxide semiconductor (CMOS) technology is continually decreasing in size. Right now, the smallest device is the Micro-Mote, which is less than a half a centimeter. This small device can be implanted in people with diseases such as glaucoma, and it can monitor the intraocular pressure. Its power source is a solar cell on the very top layer. A smaller design has been proposed that will reduce the weight and increase the reliability. Instead of having a 3D cube with layers of chips stacked on top of each other with wire bonding between each layer [1], the device can be placed all on one layer. The problem is directly integrating LEDs and solar cells onto the processor. This can potentially be done with thin-film gallium arsenide (GaAs) nanowires, which have been shown to make high efficiency light emitters and photovoltaic cells, and have the potential for integration on arbitrary substrates [2]. However, nanowires have dangling bonds that can decrease the efficiency of light emitters and photovoltaic cells. To improve the efficiency of GaAs nanowires, deposition of parylene on GaAs nanowire arrays are studied in this work to provide both structural support and surface passivation. Before testing could be done on the device, two questions about the deposition of parylene on the nanowires had to be answered: does the parylene seep in between the nanowires, if so does it reach the bottom?

Design:

The proposed design of the solar cells consists of indium tin oxide (ITO) sitting on top of the processor. GaAs nanowires are grown on top of the ITO, which are then embedded in parylene. Finally, ITO is deposited on top of the nanowires as the transparent conductor.

Methods:

Parylene is deposited on top of the nanowires using the Special Coating System Parylene Deposition System (PDS). The amount of parylene to deposit was determined by the length of the nanowires. The deposited parylene should have, approximately, the same height as the nanowires. After the parylene was deposited the sample is taken to the LAM dry etching tool to etch the parylene off until nanowires are visible. Once the etching has finished the samples are taken to the Hitachi scanning electron microscope (SEM) to see if nanowires are visible. If they are not, then etching continues until the nanowires are seen.

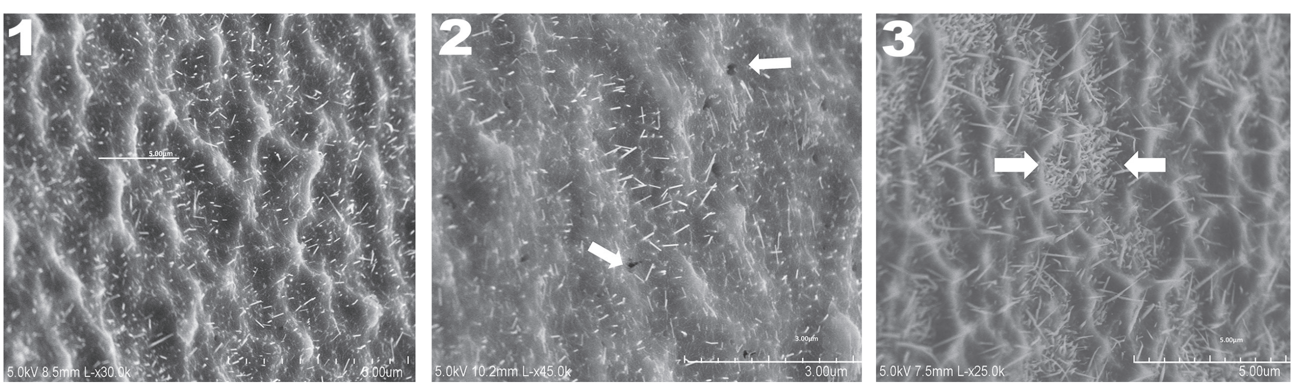

Figure 1, left: *SEM picture of the nanowires sticking out of the parylene.* ***Figure 2, middle:*** *Holes of parylene, which can mean that there is no more parylene in that area.* ***Figure 3, right:*** *Parylene does not embed in thick clusters of the nanowires.*

Results and Discussion:

The process was repeated on samples with nanowires of different heights and it was determined that the parylene does seep in between the nanowires. After several microns of parylene were etched the nanowires always started poking out as shown in Figure 1. However, although the amount of parylene deposited was the same length of the nanowires, a significant amount of parylene had to be etched before the nanowires were visible. This shows that the parylene is not reaching the bottom of the nanowires. To confirm this, etching was continued for several samples. For some samples, small holes started appearing throughout the parylene that can be seen in Figure 2. This means that the parylene is not distributed evenly, or there is no more parylene in that area. In other samples where it was etched more, small clusters of nanowires started appearing as shown in Figure 3. This demonstrates that the parylene is not seeping through those areas.

Throughout the experiment, the sample sizes that were being used were 1 cm × 1 cm. In the etch tool these samples had a different etch rate than the standard four inch wafer. It was determined that the smaller samples were etched at half the rate. This helped us determine the amount of parylene that was actually being etched. This new information helped make a device with three different etch times to see if the current was going through the nanowires with parylene passivating them. The graph in Figure 4 demonstrates that current is going through the nanowires.

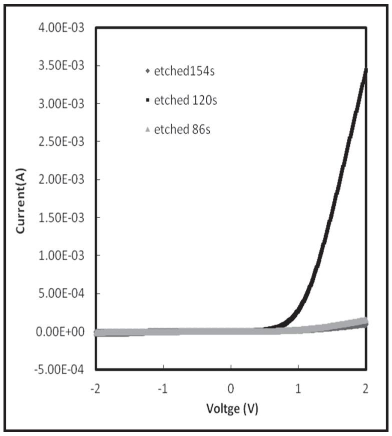

Figure 4: This graph shows that current does go through the nanowires with parylene.

Conclusion and Future Work:

Parylene does seep in between the GaAs nanowires providing some structural support and passivation, but since the parylene is not reaching the bottom of the nanowires, the nanowires are not as efficient as they can potentially be. To solve this problem a new way of depositing parylene on top of the nanowires can be experimented with. Instead of having the parylene deposited all at once, there can be several smaller cycles of parylene deposition on the samples.

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