ANFF

ACT Node News

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Passivation of Solar Cells using sputtered Al_2O_3 films

Photovoltaic solar energy is one of the fastest growing renewable energy technologies that aim to mitigate climate change. It is expected to provide between 5% (according to the International Energy Agency) and 10% (according to the photovoltaic industry) of the world's electricity by the year 2030.

One main driver in solar cell research is to improve their conversion efficiency through the reduction of surface recombination. Traditionally, thermally grown SiO_2 @ 1,000°C has been used in the labs for such purpose; however there is an industrial drive to do the passivation at much lower temperature. As a consequence, plasma deposited SiN_x is commonly used to passivate the phosphorus doped emitter region of Si solar cells. Moreover, the SiN_x layer is simultaneously used as an anti-reflection coating (ARC).

Passivating the rear, p-type side of the wafers, remains a challenge for the industry. Recent work has shown that it is best passivated with atomic layer deposition (ALD) of Al_2O_3, which is negatively charged in opposition to the positively charged SiN_x layer.

Unfortunately ALD is not yet a high throughput process, although there are already reports of newly designed machines that can perform thermal ALD at high rates.

At the ANU College of Engineering & Computer Science, School of Engineering, one of the primary goals of the PhD research performed over the last three years by Andrew Li (see Figure 1), under

Figure 1: Andrew Li depositing Al_2O_3 by sputtering at the ANFF ACT Node at ANU.

the supervision of Prof. Andres Cuevas, was to find an alternative method to deposit the dielectric layer of Al_2O_3. Andrew investigated the sputtering of Al_2O_3 films using the ANFF ACT Node flagship AJA Sputter system, comparing the reactive sputtering using Al target + O_2 gas versus an Al_2O_3 target.

Figure 2 shows this property of the sputtered Al_2O_3 as compared to other deposition methods for the same dielectric.

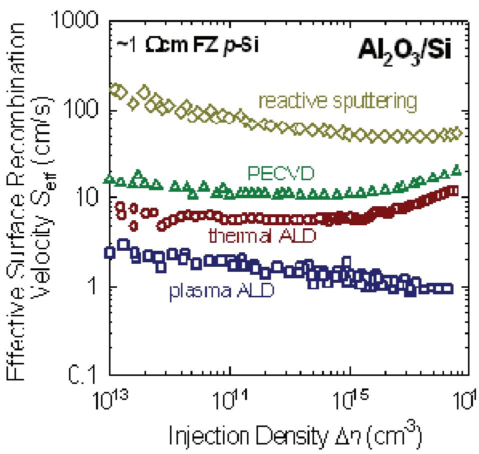

Figure 2: Surface recombination velocity of the reactive sputtering in comparison to other dielectrics.

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***It has been just over** a year since we released the first of our newsletters. That issue was distributed to 35 recipients - this, our fifth issue, is going out to more than 140 recipients, an increase of 400%! This increase, in the main, is from users of our facilities, people who have requested to receive the newsletter at conferences, etc, and even a few unsolicited requests from other sources. This increase is primarily due to our facility staff and the way they go about their business - that is, looking after you.*

Recently we conducted a survey to gauge user satisfaction, and on a scale of one to five (five being excellent) our average score was 4.1 to 4.4 over seven criteria. Let's see if we can improve over the coming 12 months!

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ACT Node information:

- The ANU facility specialises in III-V compound semi-conductors.
- The UWA facility specialises in II-VI compound semi-conductors and MEMS.
- We can provide full support with the use of the equip-ment available.
- Full pricing policy and rates are available on the ANFF website at www.anff.org.au or contact us direct for more information - see contact details overleaf.

Node Infrastructure and Process Update

All ANU facility equipment is being accessed by Australian researchers (internal as well external users from academia and industry). Below is a summary of the highlights of our work and process development over the past three months.

The EBL RAITH 150 machine has been intensively used for development work of 3-level masking: ZEP resist/Cr/SiO_x where ZEP is used as a mask to etch Cr in the ICP using Cl_2:O_2 chemistry followed by etching SiO_x with Cr-mask that is very resistant to fluorine chemistry. Also, we continued the work on bi-layer PMMA resist for first making plasmonic structures on fused silica for lift-off of a 25nm gold layer, making use of the new e-beam evaporator. These structures have shown plasmonic resonance and are now under thorough evaluation by the external user.

Nano-imprint tests were continued using PDMS mould and sub-μm patterns have been successfully obtained down to 200nm. We also started developing processes of UV-curing using quartz stamps.

Much effort has been made to investigate the various capabilities that the dual frequency PECVD system offers. Standard SiO_x and SiN_x dielectric layers are now available. Also amorphous Si and poly-crystalline Si can be deposited using SiH_4 and He. Moreover stress free (low tensile strain) SiN_x dielectric layers can be deposited at 300 and 600°C. Analysis data includes refractive index, optical band-gap, roughness and N/Si ratio (in SiN_x).

The ICP system has been accessed by several users (internal and external industry) on a regular basis, using either Cl_2-based or F-based processes. Materials like GaAs, AlN and Ge are regularly etched in the system. Our effort in the last period focused on optimising the etching of dielectric layers after optical lithography.

After retro-fitting various accessories to our FIB system it has been heavily used, mainly for general purpose milling processes. An ANU start-up company started making use of the FIB and, recently, we negotiated a preferential rate with them associated with forecasted intensive usage in the coming quarter.

The E-Beam Evaporator has been accessed by a number of ANU users and, more importantly, the first plasmonic structures were successfully made using a lift-off process based on the bi-layers of PMMA (see EBL). This was possible due to the larger distance between source and samples to circumvent excessive heating during evaporation, hence not ruining the achieved undercut of the PMMA bi-layers that facilitates the lift-off process.

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After detailed optimisation of the deposition conditions, reactive RF sputtering gave the best results. A good way of quantifying the effectiveness of the passivation is by measuring the surface recombination velocity: the lower, the better the passivation.

Although the sputtered Al_2O_3 does not perform as well as the other methods, particularly the ALD Al_2O_3, the efficiency of the solar cells jointly made by the Institut für Solarenergieforschung Hameln (ISFH) and ANU reached a confirmed value of 20.1%, thus demonstrating the potential of reactive sputtering as a suitable technique to passivate the p-type rear surface of advanced Si-solar cells. A further application of the method to boron diffused front emitters, such as those needed for n-wafer solar cells, will be the next challenge.

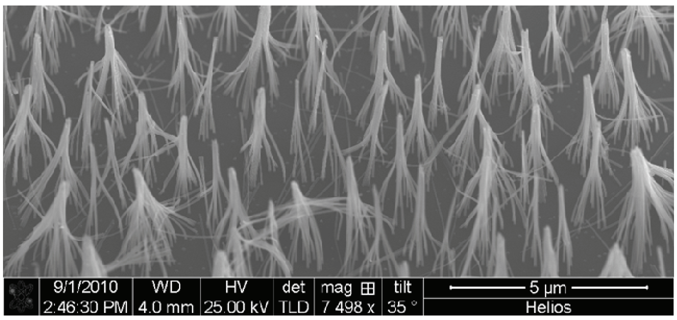
Andrew Li has submitted his thesis and is now working for the Renewable Energy Corporation (REC), a solar cell company based in Singapore.

On the Lighter Side

In an effort to reduce the lateral size of InP nanowires grown in MOCVD (research of Dr Michael Gao, EME at ANU) with a size range of 30-50nm we applied repetitive cycles of O_2-plasma and wet etch dip in diluted H_3PO_4. A side effect of the plasma exposure clustered the nanowires in bunches as shown in the SEM photograph below.

Fouad Karouta thought it bore a striking resemblance to a picture he snapped of rice being harvested on a recent trip to China (bottom).

A future food source for nano-bots, perhaps!?



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