Maskless and Contactless Patterned Silicon Deposition using a Localized PECVD Process for IBC solar cells

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Abstract:

We present a novel technique to perform contactless and mask-free patterned plasma enhanced chemical vapor deposition (PECVD) and etching. When a powered electrode with narrow slits is placed very close to the substrate, plasma is selectively ignited within the slits due to the hollow cathode effect, and so deposition or etching occurs only within an area smaller than the size of the slit. This technique is demonstrated through the deposition of hydrogenated amorphous silicon using a gas mixture of silane, hydrogen and argon. Slits as small as 1 mm generate a plasma, and for this width, the lines deposited are about 750 µm wide, homogenous over their length (60 mm), and are deposited at a rate of 50 nm/min. The phenomenon is studied using Particle In Cell (PIC) modelling. The electron localization observed in the PIC modelling provides an explanation of why the deposition is narrower than the slit. In addition, an excellent correlation between results of modeled ion flux profile and experimental etching profile is observed.

This technique offers several advantages as it allows the lithographic function to be performed (i) directly, including for high quality semiconductor layers that can be deposited using PECVD, and (ii) in a contactless fashion, as the technique does not require a mask to be in contact with the substrate, (iii) at high rates without depositing powder, and (iv) in a reactor chamber that can be also used to deposit homogenous blanket layers simply by backing the electrode away from the surface. As a result, this technique is highly suitable for the simplification of process flow in interdigitated back contact (IBC) solar cells manufacturing.

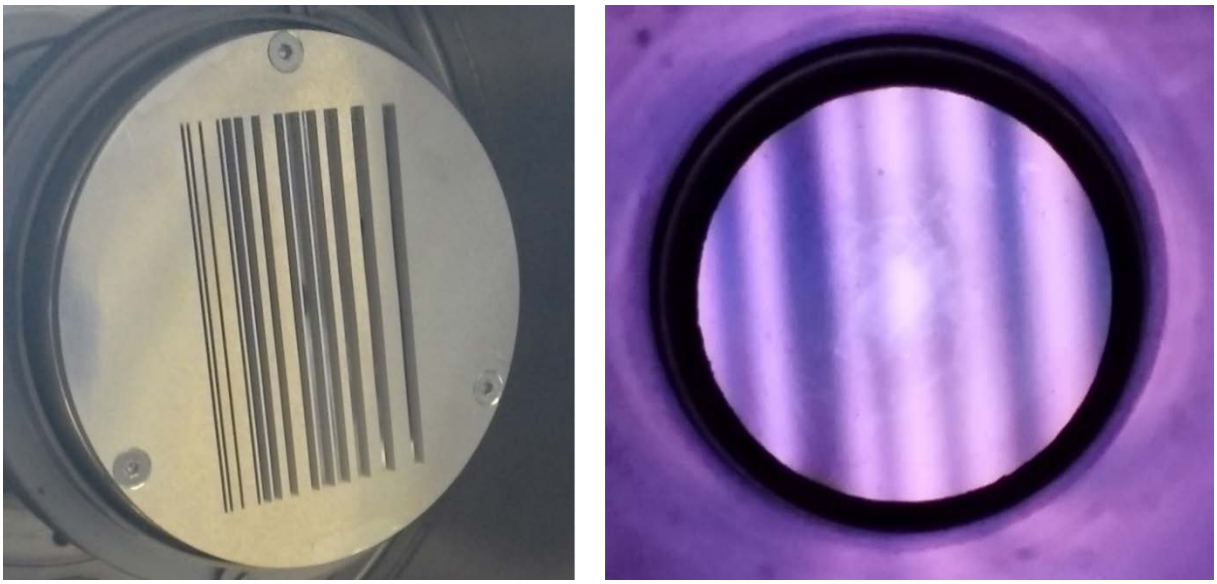

Figure 1 – a) Photograph of patterned Electrode A composed of 13 slits with different widths and spacings. The slits are 60 mm long. b) Photo taken through a transparent substrate showing ignition of plasma within slits of electrode.

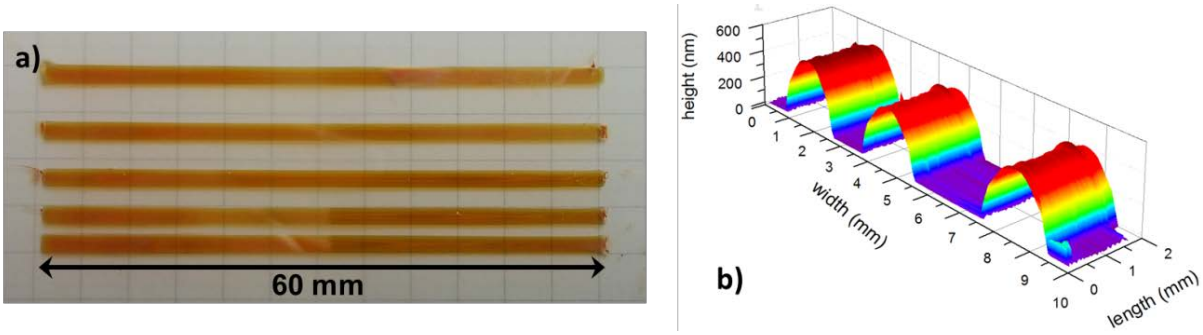

Figure 2 – a) Picture of the patterned deposition on Corning glass using Electrode A and the 2.5 mm wide slits. b) 3D mapping obtained from profilometry measurement on the lines deposited from the 2.5 mm wide slits.

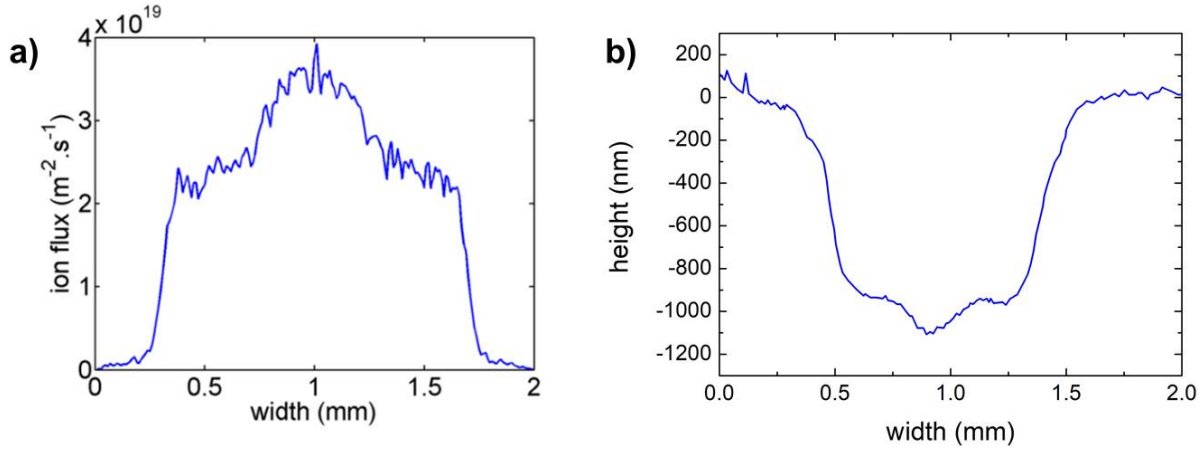

Figure 3 – a) Particle in Cell simulation of the ion flux at the substrate surface in argon plasma averaged over a RF cycle. b) Profilometry scan of a crystalline silicon wafer etched by a Ar+H_2 plasma using the patterned electrode technique