Upper left: a silicon wafer with 100 nm Al_2O_3, deposited by the Fast ALD reactor (large photo). Lower left: TNO's Roger Görtzen with the wafer.

Rapid application of uniform atomic layers

Atomic Layer Deposition (ALD) enables a uniform layer to be deposited to exactly the required thickness, atomic layer by atomic layer. The only drawback is that it is a relatively slow process. But not for long if TNO has anything to do with it.

ALD comes down to the sequential deposition of two gases, separated by a rinse gas, to a substrate surface. The first gas (A) reacts with the functional groups (ligands) adsorbed at the surface until it is completely covered. The residual gas A is then purged off. Gas B reacts with the ligands of the absorbed gas A, thereby creating a surface with the same chemical properties as the original surface. By depositing gases A and B several times sequentially, a film of precisely the required thickness is attained, atomic layer by atomic layer. The method is self-limiting because the half reactions stop once the surface is completely covered. One of the benefits of this method compared to most deposition methods is its perfectly uniform coverage of layers over high-aspect ratio features, without clogging them up. Currently ALD is used on a commercial scale only in the semiconductor industry to deposit thin uniform layers of different materials.

MOVING HEAD

Silicon wafers to be covered by a layer of material are placed in lots of fifty to hundred wafers into a vacuum reactor for a batch process. 'Two years ago the idea arose at TNO not to use ALD sequentially in a vacuum but simultaneously in atmospheric conditions. In other words, not first gas A and then gas B but simultaneously on different parts of the surface. We conceived a moving head with a number of gas extractors for gas A, gas B and the purge gas. This would move over the surface in an oven,' explains Roger Görtzen, business developer for this *Fast ALD* project. Of course, the feasibility of the reactions occurring so fast had to be investigated. This was a big 'if' among many. However, calculations revealed that the reaction rate was not a problem and so a patent application on the operation of the moving injector head formed the basis for further developments.

TNO materials experts and their mechatronics counterparts are now working on this project along with fifteen 'colleagues' from the knowledge workers scheme.

PRINCIPLE DEMONSTRATED

'We concentrated on a tool with a 2.5 x 1.5 metre footprint,' says Görtzen, 'with a throughput of up to 3,000 wafers per hour.' That is about a hundred times faster than the current process can achieve. The first application TNO is focusing on is the deposition of passivation layers of aluminium oxide on silicon solar cells. This layer has to prevent the electrons and holes created by the action of sunlight from recombining, thus not contributing to the generation of electricity. That is an application for which current ALD is too slow and not economically viable. Other deposition methods also have specific challenges. Görtzen: 'We have demonstrated the principle and are now building a prototype. The plan is to introduce a commercial tool within two years that is able to deposit a passivation layer on solar cells. *Fast ALD* is a method that could appeal to OLED, LED and *flat panel* producers as well as the semiconductor industry.'

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