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Low-k Materials - Porous Low-k

Mary Haas

Welcome to another Podcast from Air Products.

Hello, I'm Ed McKendry. Welcome to another Podcast from Air Products. Today's topic is low-k materials specifically porous low-k materials. Our guest today is Mary Haas. Mary is a PhD chemist focused in materials sciences. She is a published author and has been with Air Products for 3 years. She is also the technology lead for the Thin Film Development with a focus on porous low-k materials. Mary, thank you for being with us.

Thank you.

First question for you Mary is, what do we mean when we talk about porous low-k materials?

Well, if we look at integrated circuits silicon oxide-based glasses have actually been used for years to insulate copper wires in those circuits and as we all know processing speeds are getting much faster on our computers. To do that the feature sizes are getting much smaller and we need lower dielectric constants or better insulators to support that performance.

One of the ways to do that is to take a silicon oxide-based glass and add porosity to it. So we're actually putting nano-sized pockets of air into that film and the end result is lowering the overall dielectric constant or making the film more insulating.

So Mary, what's specifically is Air Products porous low-k offering?

Air Products has a porous material that we call PDEMs which stands for Porous Diethoxy Methyl Silane. It's a material that we co-deposit using PECVD (which is Plasma Enhanced Chemical Vapor Deposition). What we do is take two chemical precursors—one of which is an organosilane material that forms a network for our film. So it forms the basic structure of the film and at the same time we deposit a purely organic material which forms little pockets in the film which will then become the pores.

After we do this co-deposition, we use some kind of post treatment such as ultraviolet exposure to remove that organic material and what you're left with is this silicon oxide-type framework with pockets of air in it. So you end up with a low dielectric constant that you're intending.

We've done a lot of work looking at UV exposure for these films and besides just removing the porous material (the porogen) from the film, we actually also get an increase in the structural properties (in the modulus) of up to 50%. And this is pretty important, you can imagine, as you start adding these pockets of air into the film, it's much more difficult to keep mechanical integrity. So we use our UV process to get both a low dielectric constant and the high mechanical properties that you need in order for your film to be integratable.

So how long has Air Products been working with low-k materials? How specifically did this PDEMs material come about?

Air Products has actually been involved in low-k development for over 10 years and in that time as a chemical company we've been able to screen quite a variety of low-k chemical precursors including molecules that we've actually made here ourselves to tailor to the process. This gives us a database of performance characteristics that we can draw from when we're designing a low-k material and even more important than that we've drawn on our strengths in material science and chemistry so that we can have very basic understanding of the structure property relationships in our porous low-k. Things that our customers are interested in like mechanical properties, stress, pore size and pore interconnectivity, damage resistance, and even adhesion. They're all related to the composition and structure-morphology of the film. So it's really important to understand those things. So it is understanding these structure property relationships that has brought us to our current low-k offering PDEMs and our PDEMs material has arguably the best balance of materials properties for our customers' integration.

So Mary, what kind of feedback are you getting from customers on this material?

Well the other advantage to having a really fundamental understanding of film chemistry is our ability to tailor PDEMs to our customer's integration schemes. We can achieve dielectric constants down even below 2.0 and we can also tailor things like mechanical properties, carbon content, and porosity. And all of those things are going to be very important to our customers achieving integration with their various schemes.

My experience has been that customer's really value what Air Products brings to the table. You know, we want to use our materials knowledge and our technical support to get our customers over their integration goal lines faster and we really want to help them understand how to leverage chemistry.

If you could, just in closing here, can you summarize some of the key benefits of PDEMs materials from Air Products?

I have to say that I'm really proud of what we've created with PDEMs. I'm also proud of the team of very capable people that I work with. There are a number of benefits that make PDEMs different from other things that are out there. The first is that it is a PECVD solution, so it's compatible with existing technology. Our customers are familiar with it and it's not a change in processing. It also has a benefit of being extendable. We can go from dielectric constants of around 2.7 all the way down to below 2.0 and for our customers that means that they, again, don't have to make big process changes from one node to the next. We can vary that dielectric constant with pretty subtle changes in the process and the chemicals.

PDEMs itself really has the best balance of materials properties for a porous low-k dielectric and beyond that it's got Air Products expertise behind it. We really work with our customers closely in a back and forth relationship to bring them from the R&D stage all the way to production with our technical knowledge.

That sounds great. If any of our listeners wanted more information on this topic, how can they get that information Mary?

They can very free to contact me by e-mail which would be hassmk@airproducts.com .

That's great. Mary, thank you very much for being with us. Once again for our listeners, if you want more information please feel free to contact Mary Haas directly. Her e-mail address is haasmk@airproducts.com We thank you for listening and we'd like to encourage you to continue visiting airproducts.com/electronics for additional Podcasts on other topics. Thank you.

Thank you for listening to this Air Products Podcast.