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**Fiber Laser Applications Video- January 2007**
**Transcript Part II**

A couple of things about the laser you might want to see from an overall standpoint is….You've got a few components here. Of course you've got the fixtures for the parts. You've got the laser, the optical delivery system, the nozzles for gases and so forth. You've got the motion control system, in this case a PLC driven device on the robot, but you've also got a fume extraction system system. A lot of people don't think about it, but as you mill, machine, even with welding and cutting you're producing an awful lot of fine ash or powder and you breathe this in over time that's going to cause you some problems as well. Even though it's an iron oxide, we deal with materials such as silicon, crystal silicons. We deal with a lot of what are considered hazardous materials - maybe not in the solid form. But once we go into a powder form, you're dealing with 1 micron, 2 micron particle size. It gets into the lungs and you have some issues that can build up. Silicon dust is definitely one of those issues.

Silicon has become a big field for us- solar cell manufacturing, semiconductor manufactures. In the past, silicon has always been a UV application. A UV laser is nice, but they're expensive, there's an awful lot of maintenance to them. UV does very nice machining because of the wavelength but the problem is that it destroys all the optics in its own optical path so you need constant revitalizing the laser. That means you need trained staff. You need to watch the process because as these degrade the process will change. You also need to have materials on hand- these lenses cost money and then you need downtime to replace them.

Now we've gone to a one micron wavelength, in our case 1064, very close to YAG and vanadate. What they'll do- I'll give you an example from solar cell manufacturing- is have a draw tower that creates a silicon ribbon. It's not completely flat, and they'll cut out wafers and go through an annealing process to flatten them out. With a UV laser a three inch laser takes about 93 seconds to cut out. With a one micron pulsed fiber laser, because of the beam quality, you only need about 62 seconds. So it's a lot faster, and the prices are different too.

That particular UV laser goes about $144,000, minus motion control, and the fiber laser is about $17,000. So it's considerably less. And there's no need to replace parts, there's no mirrors-it's all done with fiber Bragg gratings. There's no lamps, there's no diode banks for doing the pumping. It's actually single stripe media diodes, telecom grade, that are actually good for 100,000 hours continuous use. So a little more than 10 years. For 10 years, I've got one laser that runs fat, dumb and happy and it doesn't need intervention. That means your process … isn't changing. So now I have a tool and I set my parameters based on the process and I'm not tweaking my laser based on the materials I'm dealing with. Again, it gets rid of the need for a lot of service guys. You'll have one guy servicing fifteen machines rather than fifteen guys servicing three machines.

(12:04) If you zoom in close you'll actually see we have these little copper tips, and there's a couple reasons why they're copper and why they remove like this. One is that they certainly get damaged, impingements and so forth. Two is if you look closely at these we have different diameter sizes based on what we're doing with them. So you'd pick different nozzles with different orifices based on the processes you're doing.

A larger orifice for slow flow gas is very good for welding, it helps to bring in a shielding gas for that, but if you bring it in at too high pressure it will actually draw in oxygen from the surrounding air which you don't want to do. So this is done with a nozzle and what's called a sparging head, where it's basically either metal or ceramic and they just float gas over the process to shield it. In case of a cutting application, you want high pressure – and you typically use oxygen to facilitate cutting – so you'll have a smaller orifice. But again, these do wear out. There's back reflections that go on.

But what you'll see internally here, you've got the lens. So you change the lens depending on the spot size you select, and then internally here there's also a window that is actually between where the gas delivery delivery nozzle is and the optic itself. There's a few reasons for that. One is the high pressure gas is helping to keep any materials from going back in and damaging my lens, which would be expensive. But it's also separating the high pressure gas from the lens so as I change the pressure I'm not putting any pressure on the lens itself. So I'm not changing the beam coming though that lens and changing the beam characteristic.

(13:40) I can change the beam through a couple selections: I know my fiber diameter, I know my collimator length. I can change my collimator; this is actually a plug in.. Let me show you what that is at the end of that fiber.

What we've got is – internal to here is a 50 micron fiber. It's water cooled. It's fusion spliced into a coated quartz block. There's a few reasons for this. (So there's a quartx block here.) What it's doing is, if I have 6 kilowatts in a 50 micron spot, that's a very high fluence, very high energy density. If I was to get dust, debris –certainly there's quite a bit here- or just the oils on my fingers, it's an awful lot of energy and it would burn the end of the fiber and could actually destroy the end of the fiber. A lot of companies are job shops changing these based on the process needs. What you want to do you want to expand the beam up to where the fluence is lower, the power density is lower. But also if I destroy this it's a lot easier to replace this than to have to recleave the fiber.

You'll also notice it's water cooled to take care of any thermal launching going on, and there's two gold plated pins here. And what those do, when they plug into the collimator, they close a circuit that goes all the way through the fiber. If I cut this fiber, if I break into the fiber, it shuts the laser down for safety purposes. Because again, the beam is not launching into an optical path- this (fiber) is my optical path. If I was to cut this in some way I could have laser light on the table and I could actually ruin my process, my machine and my operators or my safety guys. So there's a safety lock circuit as well.

Then you'll notice there's a keyed switch here. So when that goes in there's an optical alignment based on that. So it's very robust for replacement. We have another unit that's not here that screws onto this unit that is a quartz window that's been coated for high transmission. If they touch it and destroy it it's just a consumable they can throw away and replace. It saves quite a bit of failure in the field. Handling is important, but you'll find that a lot of people still damage these on a regular basis.

(15:52)So there are a lot of non-laser safety issues, day-to-day practices you want to get used to. One is you never want to touch an optic with your bare hands. You'll find in all of our labs we have non-powder-coated latex gloves and we dispose of these on a regular basis. You'll see acetone, you'll see in some cases MEK depending on what they need to do cleaning of the optics when they put them in the beam path. Because certainly you are touching the optics in some cases. Usually you hold them from the side. But once you've placed them certainly there is the chance to get a thumb print or finger print which can damage optics.

What you'll also notice here-this just happens to be one, there's five more inside this cabinet- is we've got a bank of different gases, nitrogen, helium, oxygen. Based on the material that we're cutting or welding we change the shielding gas appropriately. if you're dealing with a $CO_2$ laser, a lot of time you'll be using helium as a shield gas. And the problem with that it's a non-replenishing resource and it's getting very scarce and very expensive. Factories like cheap and abundant. Nitrogen is a very nice way to go- I can use it as a gas or use the liquid for a cooling process.

When you're dealing with a very thin plastic material- a capton film or an ITO film- what happens as you cut it is it will tend to stretch if it's on a membrane. So what you can do is you can actually float cooled, chilled gas through nitrogen that will fix the material and keep it from peeling back so you can keep your geometry constant.