How small is “small” at Rigaku Innovative Technologies?

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I once said off-handedly to a colleague, referencing the scale of our work at Rigaku Innovative Technologies (RIT): “Take your skyscrapers and your microns and go away…WE work on small stuff!”

But, just how small is “small”?

One of the core technologies at RIT is the vacuum deposition of multilayers, which generally is a pair of two layers of a given period (combined thickness of the repeating pair). Perhaps the most critical parameter for our multilayers is how small the individual layers are, and even more so, how small is the precision of the period of the multilayers. But, it is often very difficult to grasp how small this “small” is for our multilayers. So, before trying to create an understanding of small, I think it might work best to understand “big” first.

If you count one number every second without every stopping for anything, it takes about 11.5 days to count to a million. It takes 32 years to count to a billion. Another measure of a billion: there are about 385 billion millimeters between Earth and the Moon (240,000 miles). Okay…so hopefully that is a good sense of the size of a billion.

Now to talk about atoms, which are small. Very small. If we took all the atoms in a single drop of water (0.2 mL), and put one atom every millimeter along the path from Earth to the Moon….we could do this 50 billion times! Alternatively, put 50 billion atoms along each millimeter, along the entire 385 billion millimeters. So…atoms are very small.

The diameter of a Silicon atom is about 0.12 nanometers (about 1/8th of a millionth of a millimeter). We just covered the idea that this is very small….and are now approaching RIT’s version of “small.” Let’s look first at a typical “easy” multilayer at RIT, the 30W multilayer for elemental analysis. The multilayer period is 1.5 nanometers, or about 30 atoms across. But, the specification on the period is only 0.015 nanometers, or about 1/8th of the diameter of a Silicon atom.

Moving to one of the better CMF’s, we often make a multilayer along a four inch substrate, and along the entire length, the largest multilayer period error is 0.005 nanometers, or about 1/28th of the diameter of a Silicon atom.

But wait; there’s more! RIT recently delivered a precision concave mirror for EUV lithography used to image ultra-small defects. On this coating, the multilayer period was 7 nanometers, and the average over the optic was only 0.0048% off-target, meaning the period was in error by only 0.00034 nanometers, or about 1/428th of the diameter of a Silicon atom.

And THAT is how “small” the word small is at RIT!