Integrating cavities are the basis of an extremely sensitive technique for the measurement of very weak spectral absorptions. Basically, an integrating cavity is a closed container whose wall is a diffuse (Lambertian) reflector with a very high reflectivity. Due to the multiple reflections of light from the highly reflecting cavity walls, light will make many transits through any sample placed in the integrating cavity; i.e. the effective path length through the sample far exceeds the dimensions of the sample. For example, the effective path length through a sample that fills a cylindrical cavity whose diameter and height are both 15 cm is about 100 meters if the wall reflectivity is 99.9 percent. The result is a very high sensitivity to a very weak absorption. In addition, since the diffuse reflecting walls of the cavity produce an isotropic illumination of the sample, absorption measurements are not affected by light scattering in the sample. We previously used this approach to measure the optical absorption of pure water in the visible spectral region, and have recently obtained the first reliable measurements of pure water absorption in the UV.

Another approach to high sensitivity absorption spectroscopy is cavity ring down spectroscopy (CRDS), a very different but well-known technique. In CRDS, a sample is placed in a cavity formed by two high reflecting mirrors. A short pulse of light is injected into the cavity and bounces back and forth between the mirrors and through the sample. During each pass through the cavity and reflection from a mirror it decreases slightly in amplitude (i.e. it rings down). The rate at which it “rings down” is a measure of the sample absorption and of the mirror reflectivity. Thus, CRDS also provides a very long effective path length through the sample and is consequently an extremely sensitive technique for weak absorption measurements. But, since it cannot distinguish scattering from absorption, this powerful technique is only useful when scattering is negligible.

However, combining these two absorption spectroscopy techniques (integrating cavity and CRDS) would clearly provide an extremely powerful and useful new technology – Integrating Cavity Ring-Down Spectroscopy (ICRDS). But, ICRDS has not previously been exploited because the diffuse reflectivity of all previously known materials was simply not high enough to do ring-down spectroscopy; the losses at each reflection from the wall were so large that a light pulse would decay in just a few nanoseconds. In order to make ICRDS possible, we developed a new diffuse reflecting material that does have the required high diffuse reflectivity (e.g. 99.92 percent at 532 nm). This new material is opening new research vistas by providing very sensitive and accurate direct spectral absorption measurements of both a sample and any particulates suspended in it; and those measurements are unaffected by scattering due to the particulates in the sample. As an important example we have demonstrated the capability to measure (for the first time) the very weak spectral absorption of highly scattering biological samples.