

In this issue

Changing face of Raman spectroscopy: eighty years since its discovery

C. V. Raman announced his discovery of the Raman effect on 28 February 1928 and won the Nobel Prize in 1930. Eighty years, hence, Raman spectroscopy has transformed into a valuable analytical tool in industrial research and also as a research tool in monitoring chemical and biological processes both in time and spatial domain. In fact, Raman had used sunlight with chemical filters to generate the monochromatic light source, a prism to disperse the scattered light and a photographic plate to observe the Raman signal. In contrast, today's Raman spectrometers have sophisticated laser systems, high-efficiency reflection or transmission gratings and sensitive detectors such as charge coupled devices. Thus modern spectrometers are not only extremely sensitive to very low level signals, but are also miniaturized to the point of being used in satellites to explore the outer space and planets.

The revolution in Raman spectroscopy over the last 80 years was celebrated at the Indian Institute of Science (IISc), Bangalore, by organizing a three-day symposium in December 2008, in which leading researchers from around the globe presented their work and discussed the future directions. In particular, papers were presented from applications to biological problems to development of new techniques. In the special section, we present five selected papers which demonstrate the status of the field and its potential. The first paper by Lednev *et al.* (page 180) presents the state-of-the-art 2D correlation analyses of UV resonance Raman spectra of amyloid fibrils. The cover page of this issue depicts the dynamics of structural evolution during fibrillation. This is followed by a paper by Hamaguchi's group (page 186), which documents the development in the field, including results on the recent impact of

Raman spectroscopy to time and space-resolved studies. The exciting aspect here is the fact that one can monitor a biological process *in vivo* at both cellular and organelle levels with a spatial resolution of less than a micrometre. Hamaguchi's group has proposed the 'Raman signature of life' based on a series of well-thoughtout experiments. The paper by Ozaki's group (page 192) from Japan, highlights the importance and utility of the Surface Enhanced Raman Spectroscopy (SERS) in multi-disciplinary research. The paper also presents the details of how SERS has provided an impetus to the development of tip-enhanced Raman spectroscopy (commonly known as TERS), which is expected to lead to vibrational structural studies of molecules with a spatial resolution of nanometres. Understanding time-dependent change in molecular structures during a chemical reaction has become possible by the use of time-resolved Raman spectroscopy. Phillips *et al.* (page 202) have demonstrated the application of picosecond time resolved Raman spectroscopy in unravelling the structural mechanism associated with photo-deprotection processes. Interestingly, femtosecond time resolution has been hindered because of the 'uncertainty principle', which precluded the use of femtosecond laser pulse (these generally have large spectral bandwidths of few tens to hundreds of wavenumbers). Since the scattering phenomenon determines the spectral resolution, Raman spectral resolutions are constrained by the spectral width of the exciting laser pulse. Thus, experiments have been limited to picosecond resolution, where the vibrational line widths are generally in the order of few wavenumbers. However, to enable low spectral resolution (few wavenumber) and high time resolution, femtosecond stimulated Raman spectroscopy has been recently developed. The last paper in this special section (page 210), from our group at Indian Insti-

tute of Science, describes the discovery of a new form of Raman spectroscopy, which uses the principles of stimulated Raman spectroscopy. Here, the signals are observed as negative (LOSS) peaks and on the high energy side with respect to the excitation wavelength. This new form of spectroscopy, named as Ultrafast Raman Loss Spectroscopy (URLS), has the advantage of very intense signals compared to normal stimulated Raman, the ability to record signals even from highly fluorescent samples at femtosecond time resolution. URLS is now tipped to be competitor for Coherent anti-Stokes Raman Spectroscopy (CARS), and thus would find applications in biology and medicine in the years to come.

We hope that this special section provides a glimpse of the status and potential of Raman spectroscopy. It is apparent that with fast-developing optical technologies, and advanced theoretical and computational methods, in the near future, one should be able to record molecular vibrational structure in nanometre spatial resolution. In addition, one can also observe changes in molecular structure in femtosecond timescale, for instance, during a chemical reaction. The potential impact of such experiments become obvious when we consider the fact that it takes about 5 fs (femtoseconds) for the C=O bond in the carbonyl group to vibrate once, which corresponds to the frequency of 1700 wavenumbers. Thus Raman spectroscopy is likely to open up experimental methods to watch molecules in slow motion as they undergo chemical or biological processes.

One wonders, had Raman been alive today, how proud he would have been to see his discovery make so much impact in day-to-day research and therefore the society at large.

S. Umapathy
Guest editor

Special Section: Raman Spectroscopy