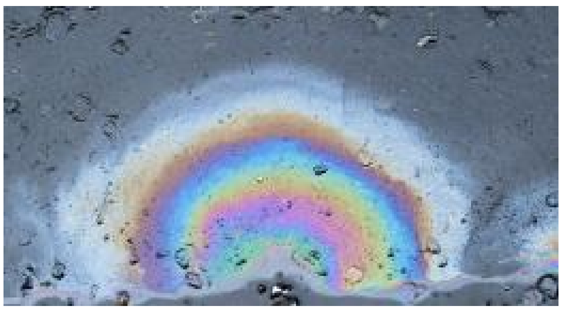
Reverse engineering materials with a rapid, non-destructive laser-based technique can aid the fight against counterfeits

September 19 2011, By Lee Swee Heng



Credit: http://en.wikipedia.org/wiki/User:John

In business, protecting a company's intellectual property can mean the difference between market success and bankruptcy. As the threat of competition from illegal copies of patented technology grows, high-tech firms are themselves turning to reverse engineering to spot potential patent infringements. Effendi Widjaja and Marc Garland from the A*STAR Institute of Chemical and Engineering Sciences have now developed a technique that promises to revolutionize reverse-engineering protocols—a rapid, non-destructive approach for mapping the composition of multilayered materials.

Multilayer films are used in the lamination of electronic components as well as sport equipment, providing multifunctional protection that single-layer films cannot, such as water and corrosion resistance, for example.

Identifying the composition of these films, however, usually involves chopping the sample up and dissolving it in solvents, a destructive and labor-intensive process. Widjaja and Garland have developed a non-destructive reverse-engineering strategies based on vibrational spectroscopy and advanced signal processing.

Scientists have long known that when excited by light, molecules emit vibrational signals that provide detailed information on their chemical and structural environments. Raman spectroscopy is a laser-based version of such a techniques that can be used with very little sample preparation and provides high precision. The difficulty in applying such analyses to multilayer films has been the volume of data generated—particles in a multilayer films have a wide range of overlapping vibrational signals, resulting in a complex readout that is hard to assign to individual substances.

Widjaja and Garland overcame this challenge by developing an algorithm called band-target entropy minimization (BTEM), in which rigorous statistical equations are used to ascertain the simplest sets of 'pure' component patterns within a vibrational spectrum. The program is extraordinarily sensitive to trace components within a material: it has been show in previous studies that even substances contributing less than 1% to the total vibrational signal information can be recovered by BTEM.

The team tested their strategy by attempting to reverse engineer the multilayer structure of a commercial packaging envelope. After shining the Raman beam onto the sample, the BTEM algorithm detected seven underlying patterns in the spectra. These patterns correspond to two forms of paper fiber, three inorganic crystalline materials and two polymers. By distributing each pure signal across the sample's dimensions, the team successfully reconstructed the spatial distributions of the components in each laminated layer.

The speed and precision of the Raman/BTEM analysis, Widjaja and Garland note, makes the technique a valuable weapon in the fight against patent infringement.

More information: Widjaja, E. & Garland, M. Reverse engineering of multi-layer films. *Materials Today* 14, 114–117 (2011).

Provided by Agency for Science, Technology and Research (A*STAR)