Light Scattering Techniques Applied to NDE

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Raman and Brillouin light scattering techniques are powerful laser-based methods to perform non-destructive evaluation of materials in the solid state. Laser light interacts with the vibrating atoms of the material under study and a very small fraction of the scattered light that emerges from the sample is changed in frequency.

Raman scattering [1] refers to the atoms within the unit cells or within molecules moving with respect to one another in various ways. Raman scattering is used to identify the nature of a material, its state of crystalline perfection or disorder, changes of phase, the presence of inclusions, and the effects of temperature, pressure and strain. A triple or single grating spectrograph is used to resolve spectral features. Our instrument is fitted with a Raman microscope allowing 2- and 3-dimensional mapping of samples. Low and high temperature stages and high-pressure cells are available. Photo-luminescence studies use the same equipment.

Brillouin and surface Brillouin scattering [2] refers to the coupled movement of the unit cells constituting both bulk and surface waves in the GHz region. Two scattering processes are operative: the elasto-optic mechanism is dominant for near transparent materials while the surface ripple mechanism dominates for those that are nearly opaque. These forms of light scattering provide powerful methods in the determination of the elastic properties of materials in bulk form and as thin films and coatings. The characteristic elastic stiffnesses determine the resistance of the material to deformation and depend on variables such as temperature and pressure, microstructure, composition and strain, and are sensitive to solid-state phase transitions. A (3+3) pass tandem Fabry-Pérot interferometer system is used in combination with a frequency-stabilised laser in order to resolve the very small changes in frequency and provide sufficient contrast.

Raman scattering studies discussed in this paper include the following:

(a) 2-and 3-dimensional stress mapping using confocal Raman microscopy in single crystal diamond in which the soft impressor technique creates plastic deformation at high temperatures [3].

(b) Measurement of stress in polycrystalline diamond (PCD) toolbits shows that the initial compressive stress in the PCD layer is removed at high temperature, thus promoting crack development [4].

(c) The use of a special electrochemical cell for in-situ determinations of the composition of the passive layer created on iron in alkaline solution by potentiodynamic polarization. The work also investigates pitting mechanisms with the addition of Cl − ions to the solution [5,6].

Surface Brillouin scattering studies discussed in this paper include the following:

(d) The elastic stiffnesses of bulk solids are determined; platinum group alloys at ambient temperature are discussed. Alloys of this type have prospective use in the next generation of gas turbine engines operating at increased temperature.

(e) The elastic stiffnesses of iron pyrite have been determined at high temperature, demonstrating the potential of the method in this respect [7].

(f) The elastic properties of thin supported hard films of carbides [8] and nitrides are measured showing the effects of the deposition parameters.
The thermally induced amorphous to crystalline transformation of argon ion bombarded GaAs is studied with surface Brillouin and Raman scattering. Each technique provides crucial information regarding the complex processes occurring [9].

In most of these cases, theoretical methods using surface Green's functions are employed in the determination of the elastic stiffnesses [2].

References


