Measurement of paper and oil paint with a very lightweight hyperspectral imaging apparatus consisting of an imaging interferometer and inexpensive bolometer camera

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A unique mid-infrared hyperspectral imaging apparatus is being studied and developed in the Kagawa prefecture in Japan. The apparatus uses an uncooled bolometer camera rather than an HgCdTe (MCT） array sensor. As they are not military devices, bolometer cameras are considerably cheaper to obtain and easier to handle than MCT array sensors.

The imaging-type interferometer is a Fourier-type spectrometer with a higher light throughput than that of the dispersion-type spectrometer. Therefore, the weak signal light from the sample can be efficiently collected and sent to the detector. Furthermore, the imaging-type interferometer has at least two advantages over the Michelson-type interferometer, which is a conventional Fourier-type spectrometer.

One of the advantages is its resistance against vibration. In general, in a Fourier spectrometer, the light is divided into two components that interfere with each other, which makes it vulnerable to vibrations that cause changes in the optical path length. However, the imaging-type interferometer is resistant to vibration because the light divided into two components passes through almost the same optical path. The other advantage is that the apparatus can be smaller; this is because the light divided into two components passes through almost the same optical path, the number of optical components is small, and the resistance against vibration makes the vibration isolation mechanism unnecessary.

In the development, many prototypes were created. In the current apparatus, a bolometer camera (FLIR Boson 320, wavelength range: 7–14 μm, pixel size: 360 × 240, brightness level: 12 bits) is used as the sensor. The total mass of the camera and spectrometer is 1.25 kg. The system also requires a projection lens, light source (lamp, power supply, and lighting lens), and laptop. The apparatus can measure accurately regardless of its direction, horizontal or vertical. In addition, the device is lightweight and resistant to vibration. Thus, it can measure accurately even from a drone.

Although a mid-infrared hyperspectral imaging apparatus could be used in various fields, this presentation is focused on measurement results of oil paints and papers, because the first author is very familiar with Fourier-transform infrared (FTIR) measurements of papers and colored materials. Eight types of paper from four manufacturers and white oil paints from six manufacturers applied on recycled paper were measured.

The light emitted from the light source (950 °C) was focused by a single lens and irradiated on a circular region of the sample with a diameter of 2.74 cm at an incident angle of 45°. When the light mirror-reflected by the sample was measured with this apparatus, different spectra were observed for each type of sample. In addition, spectra similar to those measured by another FTIR spectrometer were obtained. More detailed measurement results will be presented at the conference.