1 Why millimeter waves?

The Marveloc 602 products of Hammer-IMS use millimeter waves for its contactless sensing principle. The terminology of "millimeter waves" is a specific name for electromagnetic signals having frequencies starting from $30\,\mathrm{GHz}$, reaching up to $300\,\mathrm{GHz}$. The wavelengths [1] of these signals range from one to ten millimeters, hence their name millimeter waves. Implementations using millimeter waves have always known high costs, which prevented them from being adopted in non-lab environments. This situation is changing thanks to pushing economical and technical forces. Therefore, their inherent advantages can be brought to new applications, among which industrial sensing systems. Their inherent advantages are now briefly discussed:

Sharp time domain resolution

The high frequencies associated with these millimeter waves enable highly-precise sensing of time delays. Previously, microwave signals using lower frequencies than millimeter waves have never realized the same order of precision. Highly-precise sensing of time delays enables highly-precise distance sensing or sensing of derived quantities such as thicknesses or basis weight.

Penetration through opaque materials

Millimeter waves are non-optical electromagnetic signals. Penetration through opaque dielectric materials is an important property of them. Many of the common coloring additives (master batches) in the plastic sheet and foil industry do not block millimeter waves. Moreover their impact on the accuracy of the measurement is only limited. Only when large amounts of coloring additives are present a re-tuning of the sensor needs to take place. E.g. When more than 10% of $\mathrm{TiO_2}$, a common white-coloring additive, is present in a plastic sheet, the sensor needs to be slightly re-tuned. Similarly, millimeter-waves can be applied to detect the presence of an object behind an opaque concealing layer.

No scattering on rough surfaces

In the plastics industry, typically, surface textures are applied to sheets or films. Due to the relatively large wavelengths of millimeter waves (compared to light), geometric scattering does only occur limitedly for flat products.

Suitability for 'invisible' materials

Optically-transparent materials exert an impact on the millimeter wave signal as well. This means that millimeter waves have a competitive advantage with respect to optical systems. The latter techniques tend to fail if the sensed material both does not reflect light and does not absorb light. This is the case for e.g. transparent sheets of PMMA and polycarbonate, but also for many foils used for sealing purposes of fresh food or medical devices.

Compatibility with harsh environments

Wavelengths of millimeter waves are in the millimeter range. This causes them not being scattered by small size dust and fog particles. As a result, they are of particular interest for harsh environments. E.g. the paper industry faces contaminations by chalk and clay particles, being dispersed in the air in both production and processing plants. These compounds are applied in the production plants to give a shiny look to graphical paper. While being processed, the paper partially releases these compounds, causing harsh environments. Similarly, changing environmental-light settings makes it hard for an optical sensor to reproduce its output. Millimeter-waves are insensitive to these changing environmental-light conditions.

[1] in a vacuum environment

Detection of concealed items

As an analogy to a photo camera, millimeter-waves can be applied to capture images. Since millimeter waves can travel through various opaque materials, they can be used to sense concealed objects. E.g. full-body scanners in airports can reveal concealed weapons. E.g. aircraft can have a visual on the landing slope, even while landing in heavy fog.