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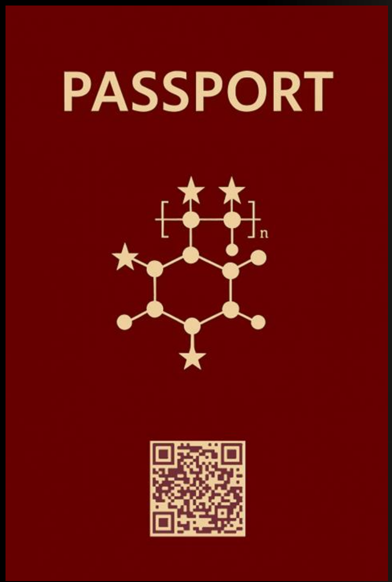


The Digital Product Passport (DPP)

with Material Authentication

Digital Product Passport (DPP) in Plastics Processing

The Digital Product Passport (DPP) is set to become a game-changer for the plastics industry. It acts as a digital twin of any plastic product, carrying verified information across its entire life cycle – from raw material to processing, use and recycling.

* **Full transparency –** clear traceability of polymers, additives and recyclate content.

* **Circular design –** enables smarter sorting, dismanting and closed-loop recycling.

* **Proof of sustainability –** documentation of CO_2 footprint, energy demand and recycled content.

* **Regulatory compliance –** aligns with EU ESPR and PPWR targets for 2030 and beyond.

Product life cycle

Traceability, Digital Product Passport & Secure Authentication

In tomorrow's packaging world, traceability is no longer a nice-to-have – it's the backbone of trust. The Digital Product Passport (DPP) gives every tube a digital identity, carrying transparent information about its origin, material composition, recyclability and even its carbon foodprint. Combined with authentication technologies, this ensures that every tube can be verified as genuine, safe and compliant – from production line to recycling bin.

For tubes in particular this matters big time:

* **High product diversity**: Tubes often look similar but differ in barrier layers, additives, or recyclability. The DPP makes these invisible differences visible.
* **Consumer trust:** Authenticity checks protect against counterfeits in the cosmetics, pharmaceuticals and food industries – markets for which safety is a top priority.
* **Recycling intelligence:** With traceable TAGTEC markers, tubes can be identified in sorting lines and routed to the right recycling stream, enabling true circularity.
* **Closed-loop innovation:** Data-rich tubes create a feedback cycle for brand owners, regulators and recyclers – ensuring design, use and recycling stay connected.

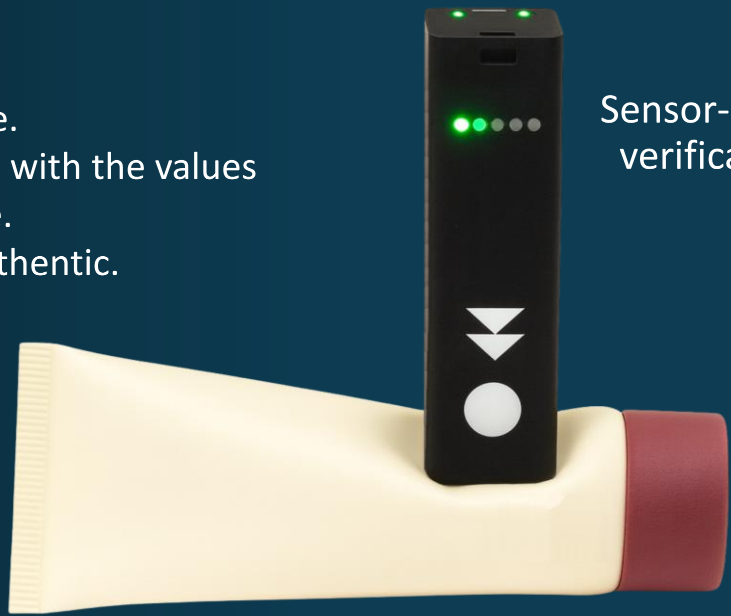
TAGTEC

TAU Reader Technology – Cutting-Edge Sensor Intelligence

With TAU Readers – available as LUMI-TAU INLINE, MOBILE and LAB – marked objects can be securely detected and differentiated by marker type.

Mobile and Lab authentication:

* Sensor data is transmitted over the air to a smartphone.
* The TAU app compares the measured marker signature with the values stored in the cloud, which is queried using the OR code.
* If the two match, the product is instantly verified as authentic.
* MOBILE and LAB units enable fast authentication in the field, at retail or in quality control labs.



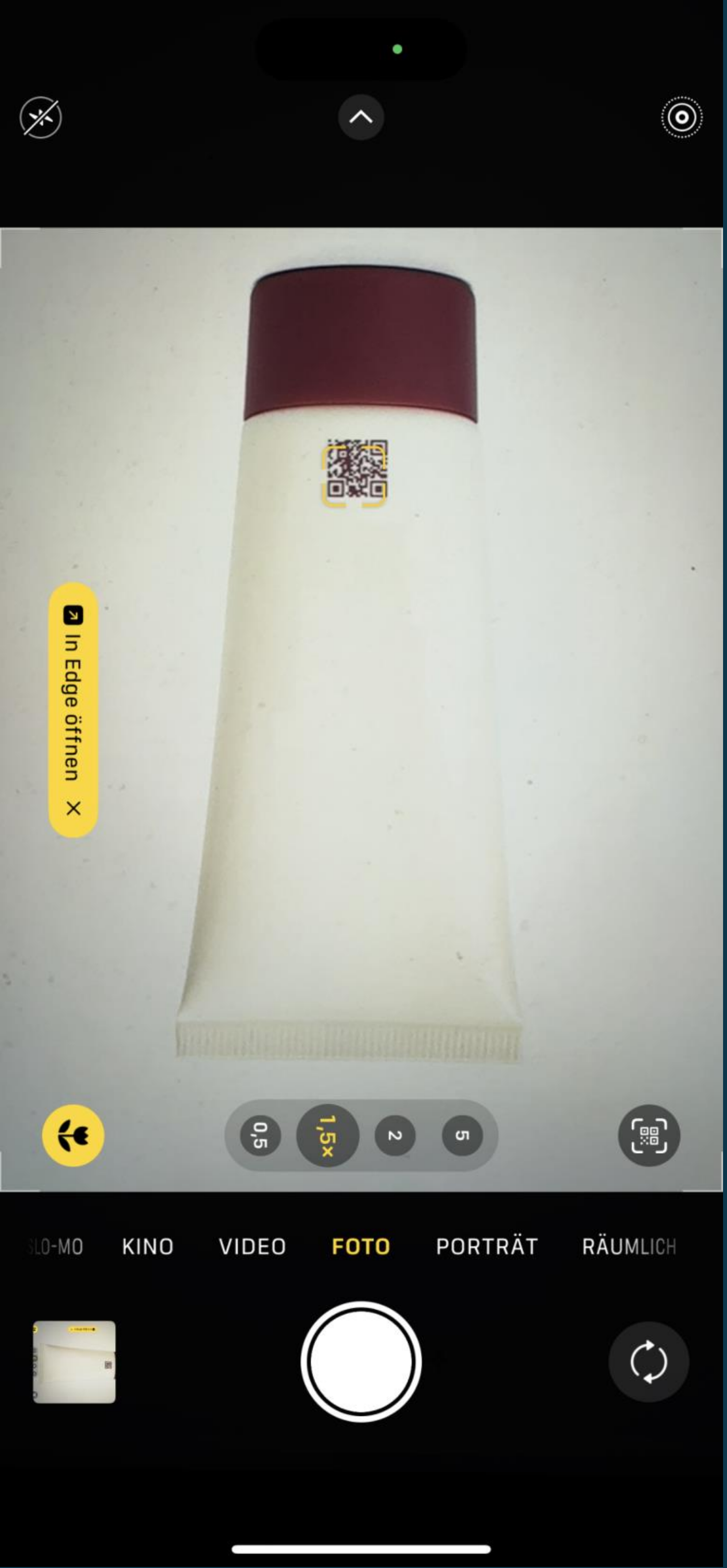
Sensor-based verification

Inline verification in production:

* INLINE systems ensure during manufacturing that each product contains the correct marker concentration.
* Only then is the item marked with a laser-engraved individual QR code, binding the physical marker to its Digital Product Passport (DPP).

Smart recycling & closed loops:

* During recycling, INLINE TAU Readers separate marked objects from mixed waste streams.
* Even after shredding and extrusion, the marker remains detectable, enabling resorting and traceability.
* When the recyclate is reused, INLINE TAU Readers measure exact marker content in real time.
* Integrated in dosing units, the required amount of marker-based master batch can be added automatically, ensuring that the new product achieves the precisely defined marker concentration.



Seamless Synergy of Sensors, Marker Technology, Smartphone Apps and the Cloud

Together, TAU Readers + Marker + QR code + Digital Product Passport create a tamper-proof chain of trust:

* Secure authentication at any stage of the lifecycle.
* Process control from production to recycling.
* Guaranteed traceability across multiple cycles.

This is sensor technology at its finest – merging cutting-edge optoelectronics, digital intelligence, and circular economy design into one seamless system.

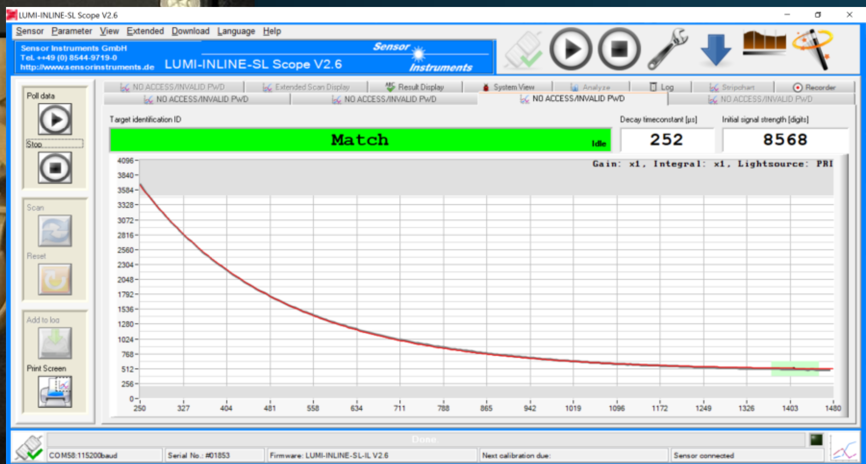
Visual inspection

Tube Shredded, QR Code Gone – But What About the Data?

That's exactly the weakness of conventional approaches used with the Digital Product Passport so far: during recycling, the information is literally shredded.
This is not the case with a marker-based system. Here, the crucial recycling information – for example food vs. non-food – remains intact even after shredding and extrusion. The inorganic, phosphorescent marker particles used are both pressure-resistant and, most importantly, temperature-resistant up to 900°C.

Different markers are deployed for food and non-food items, carefully selected to avoid interference since each is excited at a distinct wavelength. This allows flakes to be reliably sorted by marker type. And beyond sorting: in dosing units, if an excessive concentration of the "wrong" marker is detected, throughput can be automatically reduced and compensated by adding more virgin material together with TAGTEC masterbatch.

But how exactly does the TAGTEC marker work? TAGTEC stands for Taggant Technology. The marker consists of inorganic phosphorescent microparticles. Depending on the marker type, excitation takes place in the UV, blue, red or IR range. The optical echo (the secondary emission) then appears either in the visible or infrared wavelength range, depending on the marker type. Phosphorescent means that the particles continue to glow even after the excitation source is switched off. This afterglow is characteristic for each specific marker type. The key parameter here is the decay time constant (Tau), while the intensity of the secondary emission provides direct information about the actual marker concentration.



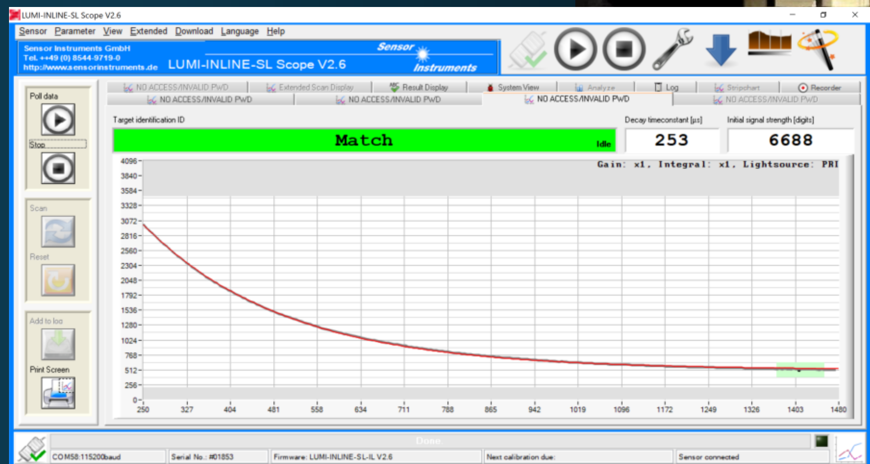
The QR Code May Melt Away, but the Essential Information Remains

While QR code recognition, tube shape, tube color, and label detection – supported by AI vision systems – still delivers valuable insights during pre-sorting, flake sorting is based solely on color, polymer type, and, most importantly, marker type. Once sorted, the flakes are fed into an extruder. At this stage, dosing units can already add color masterbatches and other additives, including TAGTEC masterbatch.

This ensures that the correct marker concentration of the recyclate is established right within the recycling facility. Downstream, on the vibrating chute, both the marker concentration and the marker type can be verified immediately before filling into a big bag, for example.

In the plastic processing plant, quality checks can be performed at several points: in the main silo, the day silo, the bag feeding unit or directly at the dosing system before the injection molding machine or extruder. If the marker concentration deviates from the setpoint, additional TAGTEC masterbatch is dosed accordingly.

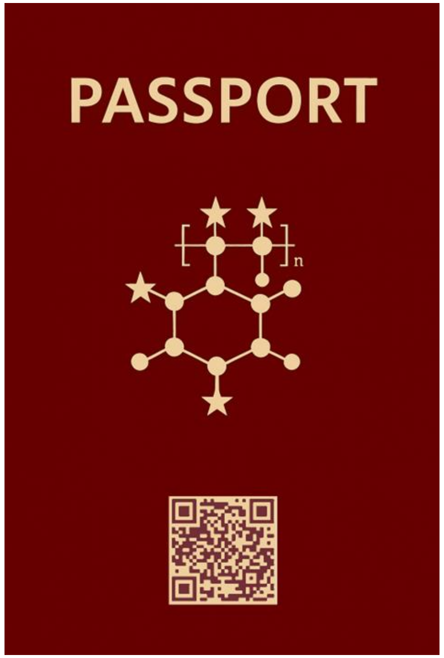
If, on the other hand, a foreign marker exceeds the allowed contamination threshold, more virgin material (also including TAGTEC masterbatch) is added to rebalance the concentration. Finally, inline marker sensors measure the marker concentration in the finished product. These readings are fed back to the dosing systems, creating a closed-loop control that continuously aligns the actual values with the target values.



Realized through Strong Partnerships

The **Digital Product Passport (DPP)** is the result of a shared vision and close collaboration among dedicated partners.

We extend our sincere thanks to all contributors whose expertise, commitment, and teamwork made the realization of this groundbreaking innovation possible.



Digital Product Passport (DPP)
with Material Authentication

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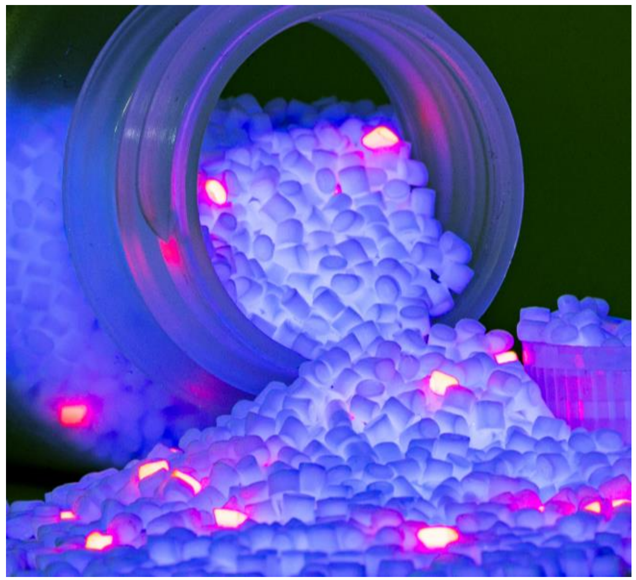

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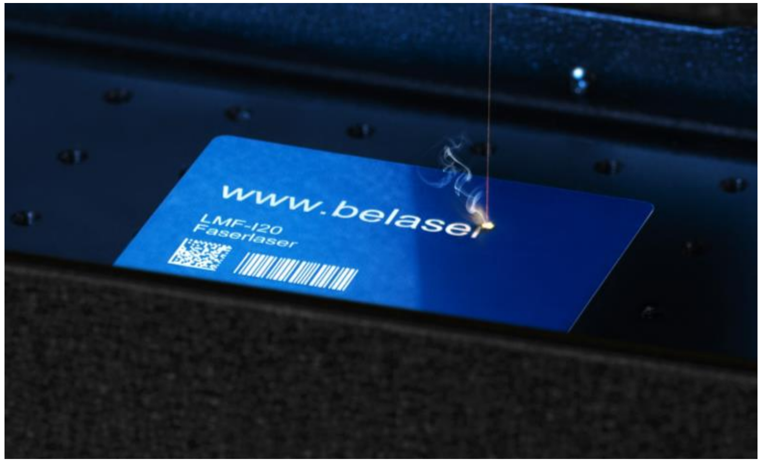

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Clarity about the Authenticity of a Product

The Digital Product Passport (DPP) with Material Authentication

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