SERIAL NUMBER RESTORATION IN METALS AND POLYMERS

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The restoration of markings (serial numbers) is an important forensic science discipline that includes the science and technology of materials. It deals with aspects of solid-state physics, chemistry, metallurgy, and engineering [1-6]. Serial numbers are applied to distinguish various items and to sign items in commercial use. In criminal cases they are removed from the items to hide their true identity. This paper presents methods used to recover the markings in metals or polymers, even when erased or blotted out. Today, a wide range of restoration techniques are used in forensic science laboratories worldwide. Various etching methods, the application of thermal energy, the use of cavitation by induced oscillation, and other techniques are discussed in detail. These technical and scientific processes facilitate the reappearance of the markings, and this is illustrated by selected examples. Finally, a practical section is offered at the end of the paper to provide practical remarks and suggestions in the application of serial number restoration. Serial numbers can be applied in various manners depending on the substrate, the base material, and its environment. Table 1 gives an overview of important methods. In metals permanent deformation occurs by changing the microstructure and by motions of line defects. The deformed crystals have physical and chemical properties which are different from those of the undeformed materials. Polymer materials consist of long molecular chains forming a more or less dense network of chemical or physical crosslinks. In this disordered state, the entropy of the system is at its maximum. If the molecular network is stretched by means of a warm stamp, the material around the marking becomes anisotropic due to local orientations of the macromolecules, and the entropy is lowered. After erasing, an area of oriented material may remain under the bottom of the marking. Heating this sample to the glass temperature, the molecule chains are forced back into their originally, statistically coiled deformation: memory effect by entropy elasticity [7]. In ABS plastic material there are good results using clove powder (Eugenol) as a swelling agent [8, 9]. In case of transparent polymers, such as polymethylmethacrylate or polycarbonate, markings can be made visible between crossed polars since orientated macromolecules exhibit birefringence. If the material (metal, polymer) at the bottom of an erased marking has a hardness different from the rest of the material, the mark appears as a relief when the sample is polished. Table 2 gives an overview of restoration procedures in metals and polymers including the status (validated or under development), and the type (destructive or non-destructive). Today the standard method for serial number restoration in metals is acid etching. The question that arises from this metallographic method is whether or not this is the best one for recovery. Therefore, several recovery procedures based on different property changes are and were the basis of a research program in the Forensic Science Institute of the BKA [see table 2]: chemical, ultrasonic cavitation [10], magnetic particle method, heat treatment, and hardness profile measurement [11], see fig. 1.

References:

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Table 1: Overview of marking methods

Method	Remarks
Die stamping	Press marking, also called “conventional stamping”: cold working for metals; hot working for plastics.
Stylus / pin marking	Cold spinning operation: performed by a portable and non-portable dot marker. The physical principles are the same as in die stamping or rolling: the material is being deformed beyond its elastic limit resulting in a permanent mark.
Roll marking	Cold presswork method: is used for marking the periphery of cylindrical or solid circular work pieces.
Type wheel marking	Cold presswork method: vehicle markings made in a hydraulic press with preprogrammed or computer controlled typewheels.
Engraving	Chip cutting operation: the substrate is cut away by a tiny spinning head leaving marks such as the serial number.
Scribe marking	A combination between cold spinning and engraving method, producing only micro-chips (micro-machining cutting).
Laser beam marking	Metals and polymers are marked by an intense laser beam in computer controlled systems. The amount of heat imported from the laser beam is able to alter the structure in the material (steel or plastic). This phenomenon is called the heat affected zone. CO_2 or YAG laser systems are used to produce VIN labels in metals and plastics.

Table 2: Restoration procedures for metals and polymers

Method (for metals)	Status	Type
Chemical etching	Validated	Destructive
Electrolytic etching	Validated	Destructive
Heat treatment	Validated	Destructive
Ultrasonic cavitation	Validated	Destructive
Magnetic particle procedure	Validated	Non-destructive
Hardness profile measurements	Validated	Non-destructive
Relief polishing	Validated	Non-destructive
X-rays (transmission)	Under development	Non-destructive
X-rays (reflection)	Under development	Non-destructive
Scanning acoustic microscopy	Under development	Non-destructive
Electron channeling contrast	Under development	Non-destructive
Method (for polymers)	**Status**	**Type**
Swelling	Validated	Destructive
Heat reatment	Validated	Destructive
Clove powder treatment	Validated	Destructive
Relief polishing	Validated	Non-destructive

Fig. 1.: Restoration Procedure „Hardness Profile Measurement“ (schematic)