B114 Polymer Replication of Reference Bullets Using Advanced Casting and Metal-Coating Techniques

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After attending this presentation, attendees will understand the concepts of creating polymer replicas from reference bullets. Vacuum-degassing and pressurization techniques are discussed for removing micro-bubbles. Sputter-coating techniques are also discussed which give hard-coating surfaces to the replicas, thereby increasing the durability.

This presentation will impact the forensic science community by providing a high-quality method for the transfer of evidence between jurisdictions. This normally results in a chain-of-custody issue; however, the transfer of replicas instead of original evidence allows agencies to work together in solving violent crimes. The sharing of evidence could lead to breakthroughs in criminal cases where it was not previously possible.

This presentation describes the polymer casting/replication and metal-coating techniques that are being used at the National Institute of Standards and Technology (NIST) to improve the quality and durability of replicated reference bullets using polymer casting methods.

Tool marks created by a firearm on a bullet or cartridge case are very important in the forensic examination of violent crimes. In many cases where violent crimes are committed in multiple jurisdictions, the transfer of ballistic evidence from one jurisdiction to another would be beneficial in helping to solve these cases; however, the transfer of ballistic evidence from one laboratory to another is typically not possible due to chain-of-custody requirements. The replication of ballistic evidence using polymer casting techniques is a perfect solution to this problem. High-quality replicas of the bullets can be distributed and analyzed, preserving chain-of-custody requirements of the original evidence.

NIST has been developing a polymer replication technique based on earlier work at the Bundeskriminalamt in Germany.[1] A vacuum-degassing process has been developed that removes the majority of micro bubbles from the replication materials during mixing. Pressurized chambers are also used during the curing phase to eliminate any remaining bubbles from the material so that near-perfect replications of the original bullets are created.

The process of making a replica bullet is explained with emphasis on the vacuum-degassing and pressurization steps that are necessary in creating clean replicas free of micro-bubbles. Comparisons of the replicas to the original master bullets are performed by measuring or imaging the striated features. Optical bright field microscopy is used for qualitative comparisons and high-resolution measurements of the surface topography are performed using disk-scanning confocal microscopy and surface profilometry. Analysis of the surfaces using mathematical correlation algorithms is then performed to make objective comparisons of the replicas and quantify their similarity to the master bullets.

The NIST Standard Reference Material (SRM) 2460 Bullets are used as a basis for the replications. The SRM bullets were originally manufactured using a computer numerical control-based diamond turning process. This is a highly repeatable process that precisely machines the striated markings onto the bullet surface. The surface topography of these bullets is well defined and each one is virtually identical to the other. Validation of the replication process is possible through the quantitative analysis of the SRM bullets and their replicas.

Durability of the replicas has also been investigated. Due to the relatively soft nature of polyurethane, additional hardening of the surfaces is required for the replicas to be durable enough for forensic work. A metal sputter-coating process is used that coats the replicas with a very thin layer of metal. The specific type of metal coating can be varied depending on the application. A thin layer of gold coating is an excellent barrier to tarnish/aging of the base material. It also reduces static charging and can be useful if scanning electron microscopy analysis is utilized in the examination. If additional hardness is required to reduce the risk from handling or abrasives, the gold coating can also be combined with other elements such as chromium or platinum. These coatings leave an excellent finish that is both durable and good for use with optical inspection methods. The sputter-coating process will be discussed, as well as additional correlation analysis showing comparisons from before and after the coatings.

Reference:

1. A. Koch, J. Katterwe, Castings of Complex Stereometric Samples for Proficiency Tests in Firearm and Tool Mark Examinations, *AFTE Journal*, vol. 39 (4), 2007

Bullet Replication, Polyurethane Casting, Sputter Coating