The best of both worlds: A new take on metal-plastic hybrid 3-D printing

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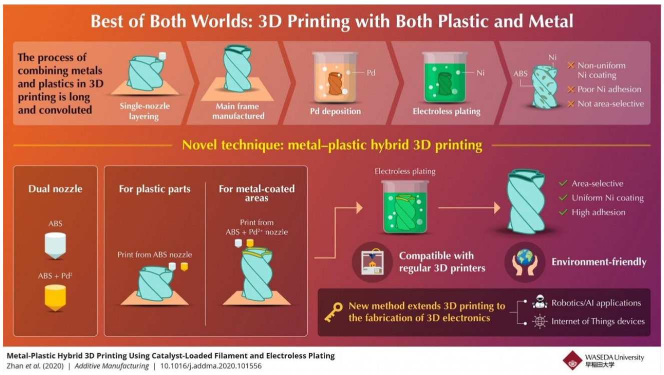
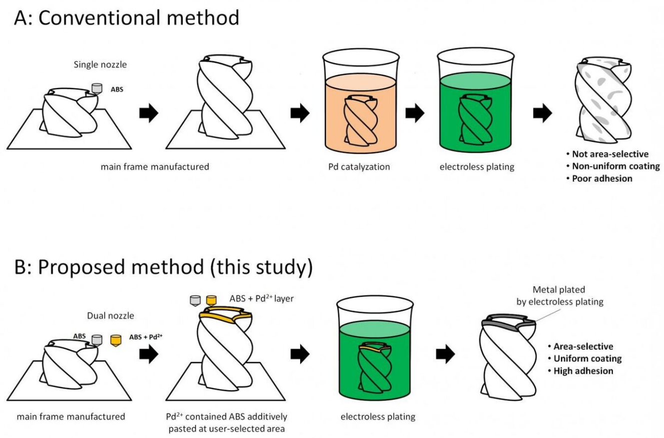


An approach that extends the use of 3-D printers to 3-D electronics for future robotics and Internet-of-Things applications Credit: Waseda University

Three-dimensional (3-D) printing technology has evolved tremendously over the last decade to the point where it is now viable for mass production in industrial settings. Also known as 'additive manufacturing,' 3-D printing allows one to create arbitrarily complex 3-D objects directly from their raw materials. In fused filament fabrication, the most popular 3-D printing process, a plastic or metal is melted and extruded through a small nozzle by a printer head and then immediately solidifies and fuses with the rest of the piece. However, because the melting points of plastics and metals are very different, this technology has been limited to creating objects of either metal or plastic only—until now.

In a recent study published in *Additive Manufacturing*, scientists from Waseda University, Japan, developed a new hybrid technique that can produce 3-D objects made of both metal and plastic. Professor Shinjiro Umezu, who led the study, explains their motivation: "Even though 3-D printers let us create 3-D structures from metal and plastic, most of the objects we see around us are a combination of both, including electronic devices. Thus, we thought we'd be able to expand the applications of conventional 3-D printers if we managed to use them to create 3-D objects made of both metal and plastic."

Their method is actually a major improvement over the conventional metallization process used to coat 3-D plastic structures with metal. In the conventional approach, the plastic object is 3-D-printed and then submerged in a solution containing palladium (Pd), which adheres to the object's surface. Afterwards, the piece is submerged in an electroless plating bath that, using the deposited Pd as a catalyst, causes dissolved metal ions to stick to the object. While technically sound, the conventional approach produces a metallic coating that is non-uniform and adheres poorly to the plastic structure.



Overview of the conventional and the proposed method for the metallization of a 3D-printed plastic structure. Unlike the conventional technique, the proposed dual-nozzle approach produces 3D objects with a uniform and strongly adhered metallic coating in desired areas only. Credit: Shinjiro Umezu

In contrast, in the new hybrid method, a printer with a dual nozzle is used; one nozzle extrudes standard melted plastic (acrylonitrile butadiene styrene, or ABS) whereas the other extrudes ABS loaded with $PdCl^2$. By selectively printing layers using one nozzle or the other, specific areas of the 3-D object are loaded with Pd. Then, through electroless plating, one finally obtains a plastic structure with a metallic coating over selected areas only.

The scientists found the adhesion of the metal coating to be much higher when using their approach. What's more, because Pd is loaded in the raw material, their technique does not require any type of roughening or etching of the ABS structure to promote the deposition of the catalyst, unlike the conventional method. This is especially important when considering that these extra steps cause damage not only to the 3-D object itself, but to the environment as well, owing to the use of toxic chemicals like chromic acid. Lastly, their approach is entirely compatible with existing fused filament fabrication 3-D printers.

Umezu believes that metal-plastic hybrid 3-D printing could become very relevant in the near future considering its potential use in 3-D electronics, which is the focus of upcoming Internet-of-Things and artificial intelligence applications. In this regard, he adds, "Our hybrid 3-D printing method has opened up the possibility of fabricating 3-D electronics so that devices and robots used in healthcare and nursing care could become significantly better than what we have today."

This study hopefully paves the way for hybrid 3-D printing technology that will enable us to get the best of both worlds—metal and plastic combined.

More information: Jing Zhan et al, Metal-plastic hybrid 3D printing using catalyst-loaded filament and electroless plating, *Additive Manufacturing* (2020). DOI: 10.1016/j.addma.2020.101556