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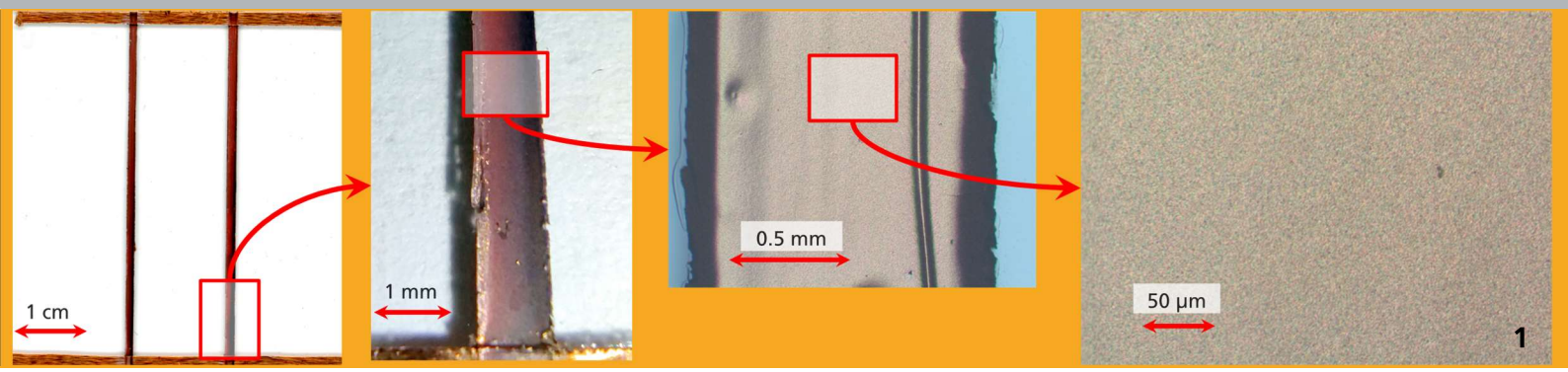

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FLAME CURING OF COPPER INKS

Fraunhofer Institute for Applied Polymer Research IAP
Geiselbergstraße 69
14476 Potsdam, Germany

Dr. Manuel Gensler
phone +49 (0) 331 568 1913
manuel.gensler@iap.fraunhofer.de

Dr. Andreas Holländer
phone +49 (0) 331 568 1404
andreas.hollaender@iap.fraunhofer.de
www.iap.fraunhofer.de
www.polymer-surface.com

Summary

Flames were applied for producing electrically conductive structures with high productivity from non-conductive, metal-containing coatings. The heat of the flames is used for the conversion. The supply of suitable reactive species produced in the flame promotes the conversion additionally and minimises the oxidation of the metal particles. This combined effect results in very low exposure times in the range of milliseconds for the conversion.

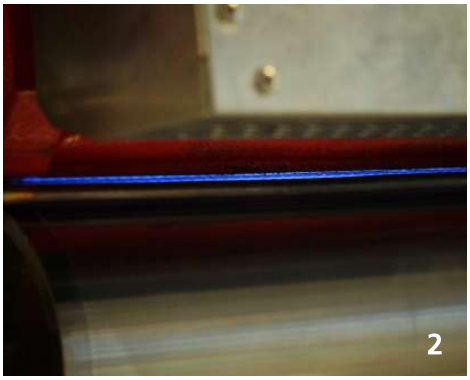
Advantages:

- low cost equipment
- fast conversion
- versatile approach

Background

Flame treatment of polymer films is done on a large industrial scale for surface activation. The flame serves as a source of highly reactive chemical species such as oxygen radicals or hydroxyl radicals, which react with the surface.

Metal-containing inks can be applied in making conductive tracks. The metal is usually present in the form of particles or as a metal complex. In most cases, a conversion process step is necessary to achieve sufficient conductivity. These processes are mostly thermally initiated. The conversion is done by classical heating, lasers, plasma or flash lamps. Each of these approaches has



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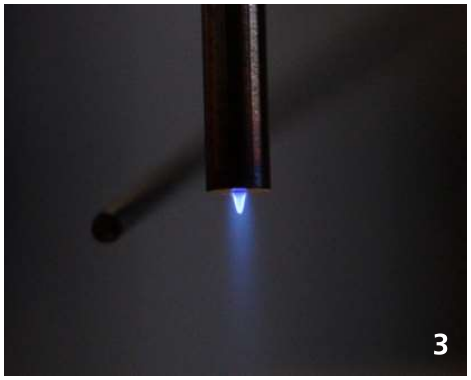

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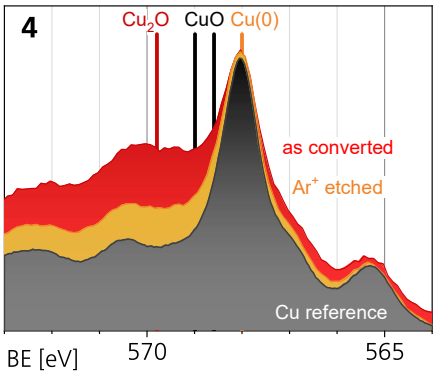

some disadvantages: Plasma and heat treatment are quite time-consuming. Laser treatment and the treatment with flash lamps requires a rather complicated and expensive equipment. Moreover, if sintering is carried out under normal atmospheric conditions, the oxidation of the metals can also prove problematic.

We found that flames can very efficiently convert the inks into conductive layers (patent pending).

Flame conversion of Cu inks

Flame treaters are available in various shapes, configurations, and sizes. Large areas can be treated with linear burners of several meters in length. At the other extreme, small burners like used for welding or even capillaries can be used to treat small areas and tracks.

For evaluating the potential of the confined conversion of ink coatings, experiments were performed using small capillary flames. Flames created with 0.25 mm steel capillary can produce heat with a power in the range between 5 W and 200 W focussed on an area in the size of 1 or 2 mm. Depending on the composition of the burning gas the chemical species produced in the flame can have oxidizing or reducing properties. The latter can be supported by surrounding the flame with an inert gas such as nitrogen or argon in order to avoid the influence of oxygen from the surrounding atmosphere.

Oxygen and treatment time are especially critical in the conversion of copper inks. Due to the high oxidation potential, copper is mostly cured under inert or reducing atmosphere. Using flame conversion, copper tracks can be prepared under normal atmospheric conditions on an ink made for fast laser curing, but with vastly cheaper equipment. At a treatment velocity of 0.2 m/s the treatment duration is 5 ms.

Properties of converted tracks

In a case where a coating is partially converted with a microflame, tracks with a width in the range of 1 mm can be produced. First experiments resulted in conductivity values in the sub-1 % range with respect to the bulk metal conductivity.

The ink deposition and conversion works on glass, but also on polymer films as polyimide.

Fraunhofer IAP

Fraunhofer is Europe's largest applied research organization and maintains 76 institutes all over Germany as well as a number of branches and offices in Europe and worldwide. The Fraunhofer Institute for Applied Polymer Research IAP develops materials, processes and products that are tailored to meet the special requirements of polymer applications. There is extensive experience in the field of organic and printed electronics.

The surface technology group has profound experience in the surface functionalization of polymers for a wide variety of applications using various technologies.