



# **Base Metal Paste for Photovoltaic Application**

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Conference & Exhibition**

# DuPont: the Leading Specialty Material Supplier in PV

## Solamet<sup>®</sup> Metallization Pastes



Driving higher energy  
conversion efficiency

## Tedlar<sup>®</sup> Backsheet Films



Protecting PV  
modules

## Elvax<sup>®</sup> and Ionomer Encapsulants

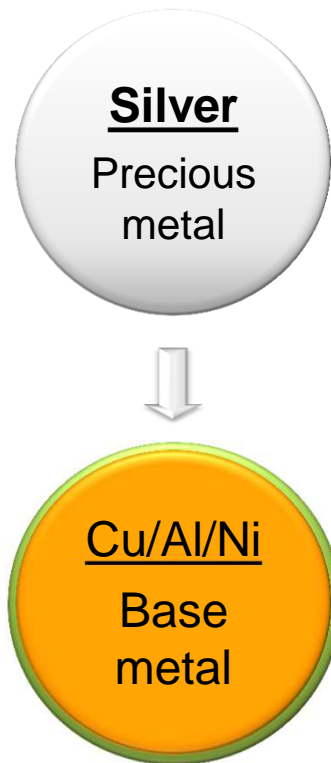


Delivering long term  
protection of cells

## Motivation for Silver Replacement

Silver paste is one of the most critical and expensive products in the PV and other electronics applications. There is a strong driving force to further lower the cost by replacing silver with much cheaper base metals (Cu, Al or Ni) in metallization paste.

### Powder Cost



### Technical Barrier



easy oxidation of  
base metals in air

### Performance

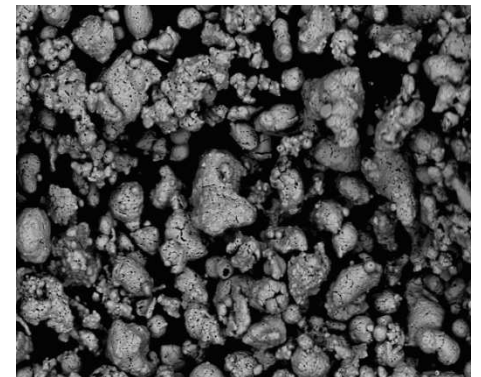
Metal	Resistivity (ohm-cm)
Silver	$1.6 \times 10^{-6}$
Copper	$1.8 \times 10^{-6}$
Aluminum	$2.8 \times 10^{-6}$
Nickel	$7.0 \times 10^{-6}$

## Technical Challenges and Solutions

**Technical challenge:** *easy oxidation of base metals when fired in air*

**Current solutions on market:**

- **Fire the base metal paste in inert atmosphere:**
  - *Could obtain high performance fired base metal pastes*
  - *High cost, hard to control the atmosphere for quality control*
  
- **Use silver-coated base metal powders**
  - *Good performance in ambient conditions*
  - *Oxidation in air-firing process*
  - *Long-term reliability issues, esp. with electrical current.*



# DuPont™ Base Metal Paste Maintains Conductivity After Air Firing

## Base metal paste:

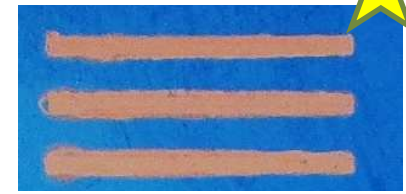


## Paste after firing:

### Ag-coated Cu



### DuPont BM



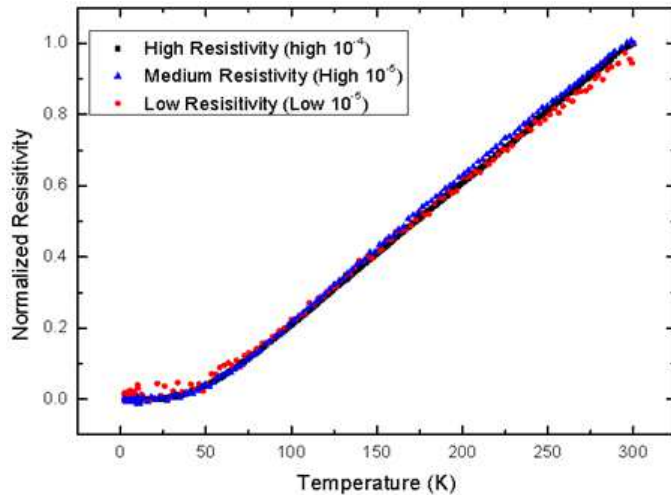
### Pure Cu



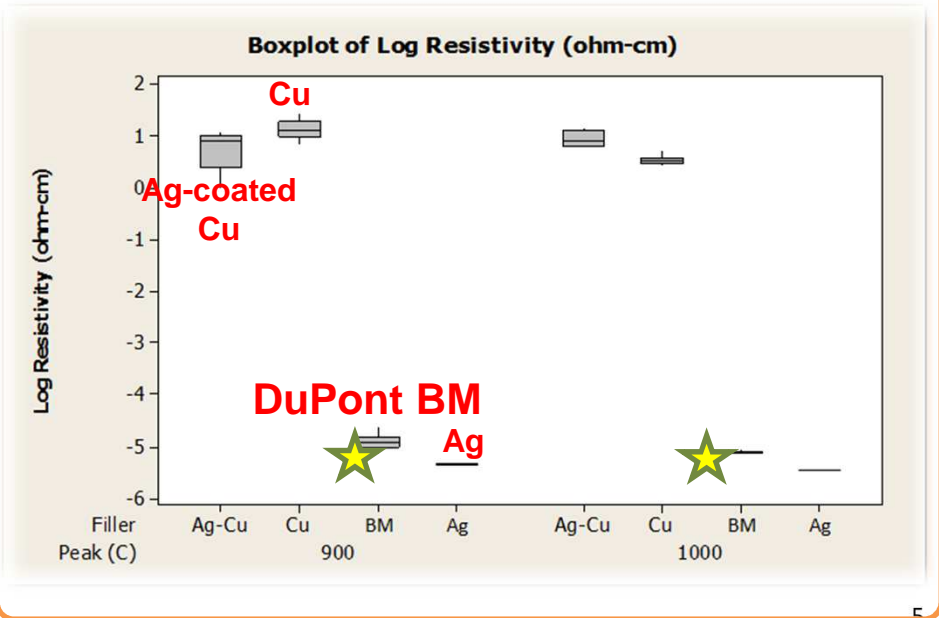
### Ag



## Metallic interconnection:

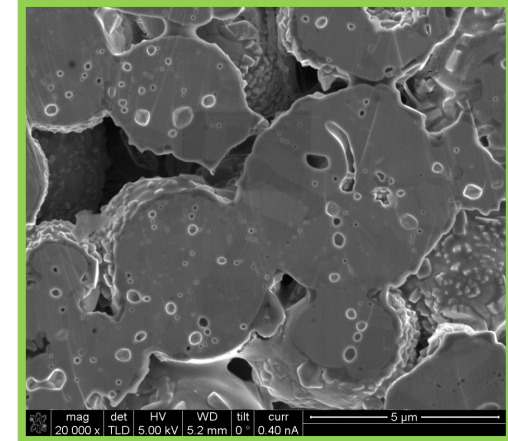
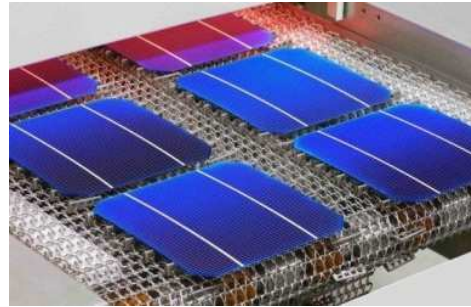


Temp. coefficient of resistance:  $\sim 0.0033$ , similar as Cu crystal of 0.0039,



# Excellent Performance of Base Metal Paste

**Air-firable!**



L. Xin and M. Bao

➤ **Low resistivity achieved by metallic interconnection**

I. Lowest resistivity currently reached  $7 \times 10^{-6}$  ohm-cm

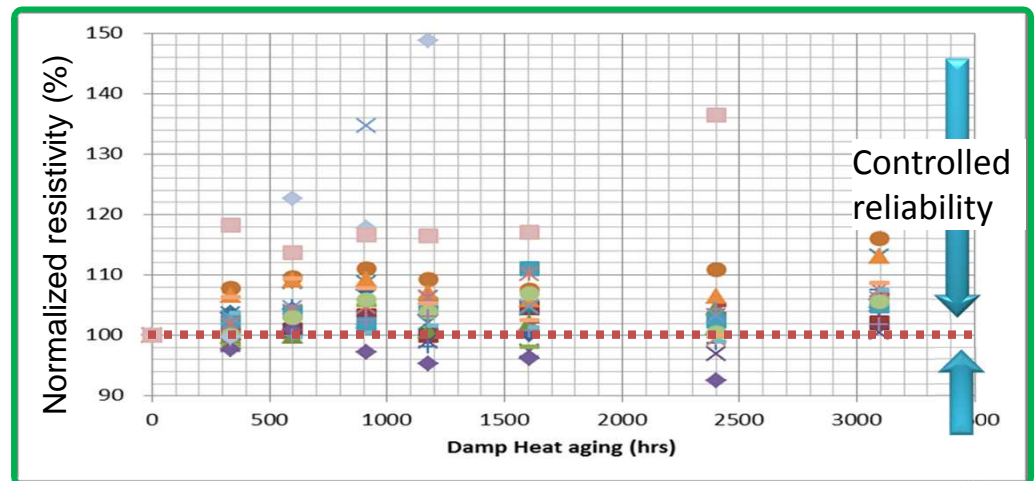
II. Cu powders show good metallic interconnections

➤ **Excellent reliability and durability**

The **unencapsulated** fired BM paste showed stable conductivity and color after up to 3000h in damp-heat aging conditions (85 RH% and 85 °C)



Resistivity change can be controlled within +/- 5% by manipulating BM paste design

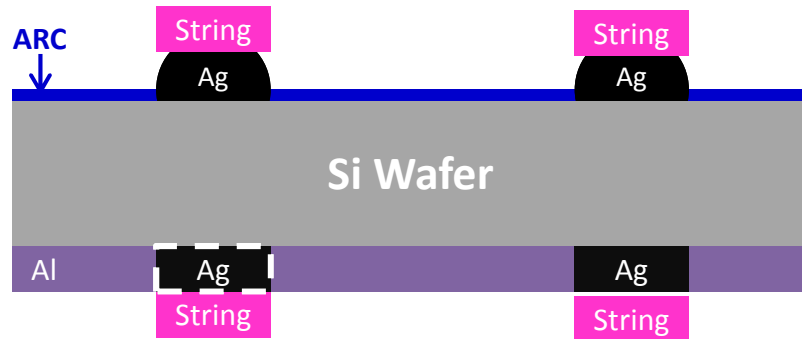


# Multi Generation Opportunities to Replace Ag

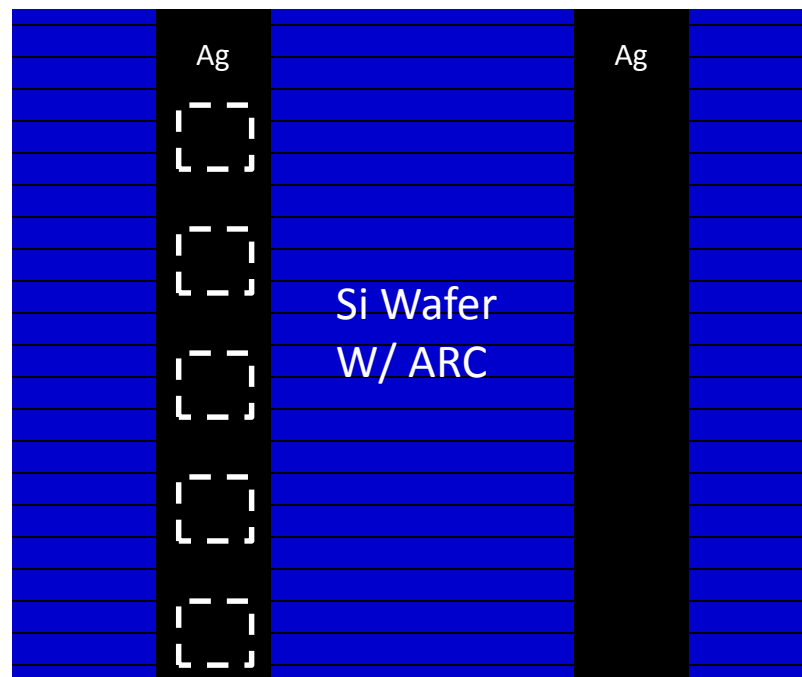


## Current market space

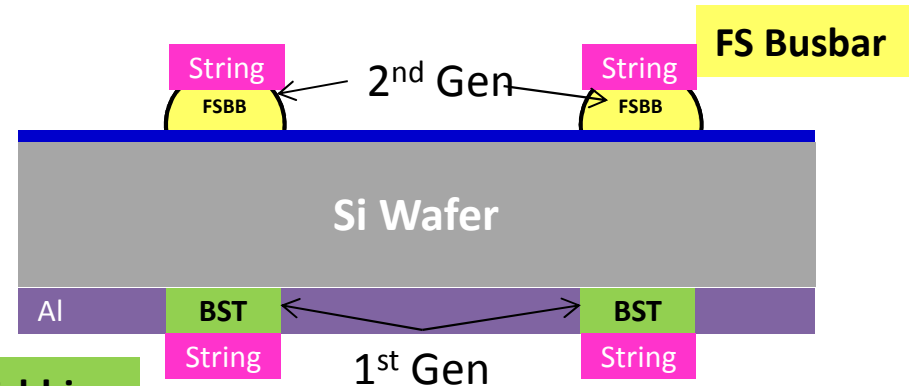
SIDE VIEW



TOP VIEW



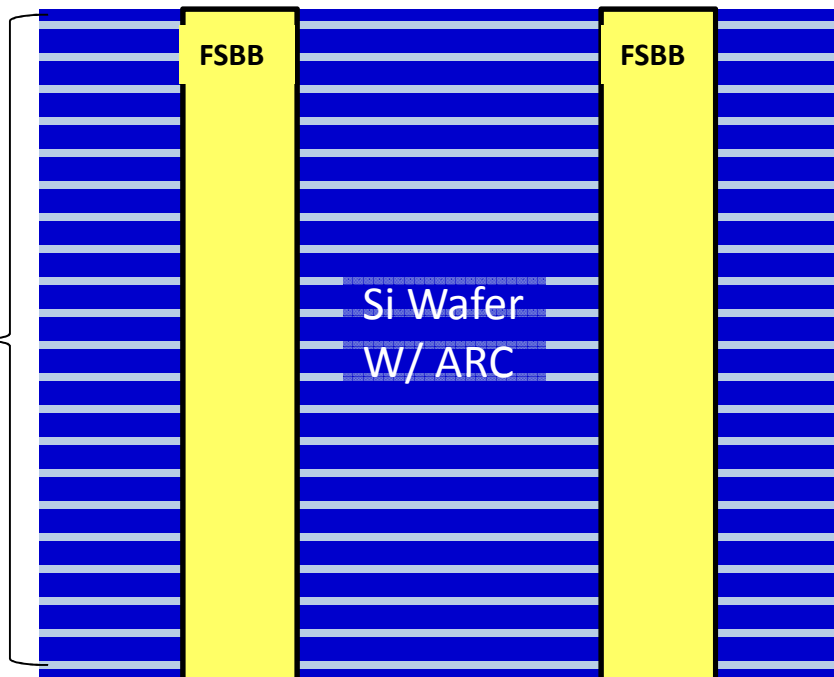
## Replaced Ag Solution



BS Tabbing

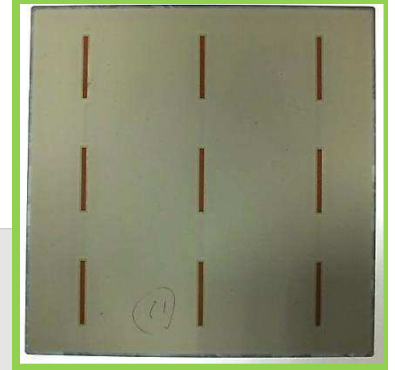
FS Fingerlines

3rd Gen

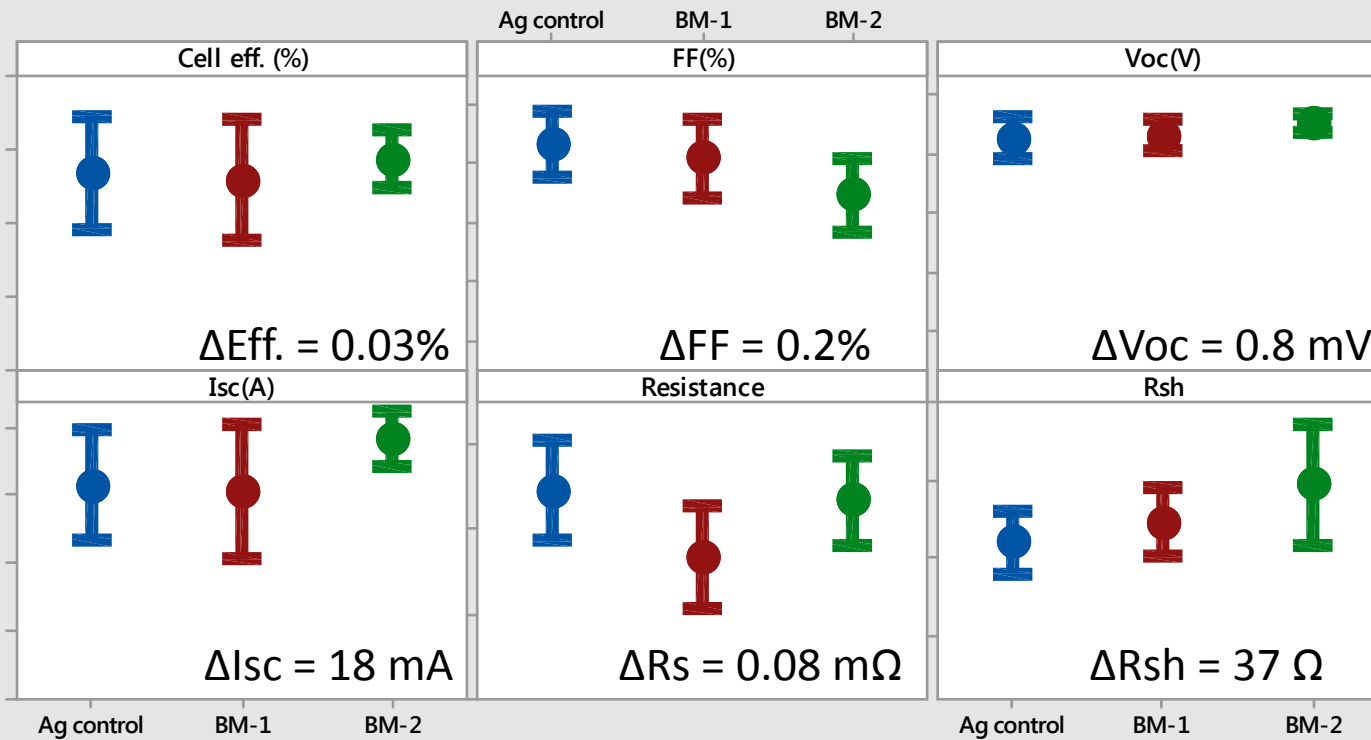


# DuPont™ Base Metal Paste as Backside Tabbing

## Equivalent IV Performance as Ag on Multi Cells



Interval Plot of Cell eff. (%), FF(%), Voc(V), Isc(A), Resistance, Rsh  
90% CI for the Mean

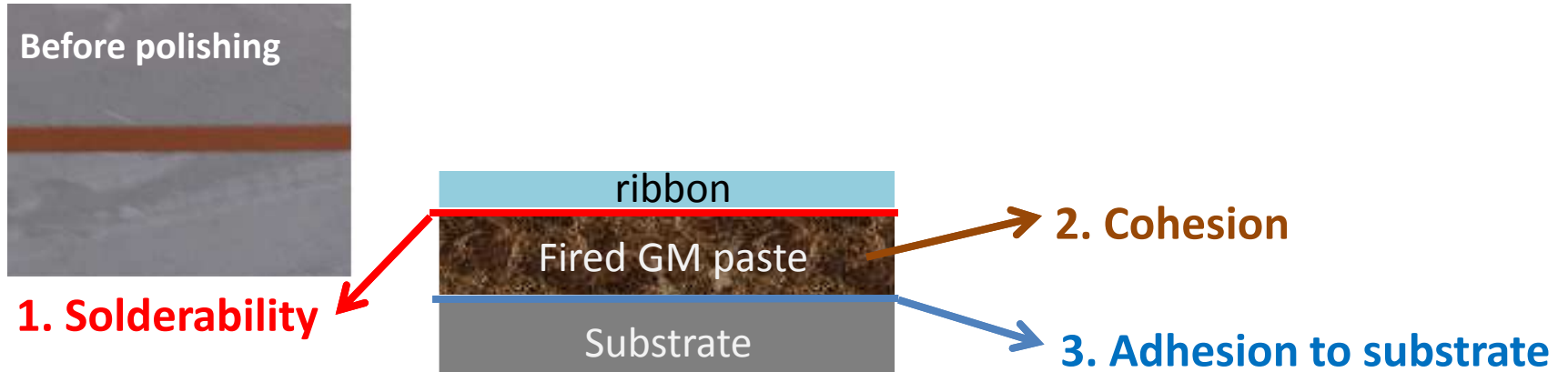


BS tabbing

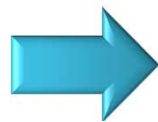
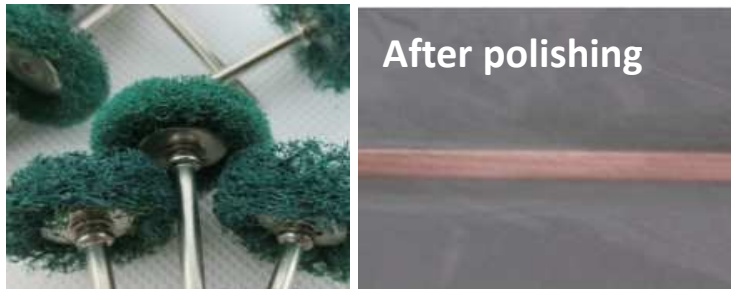


# Adhesion/Peel Strength for Backside Tabbing

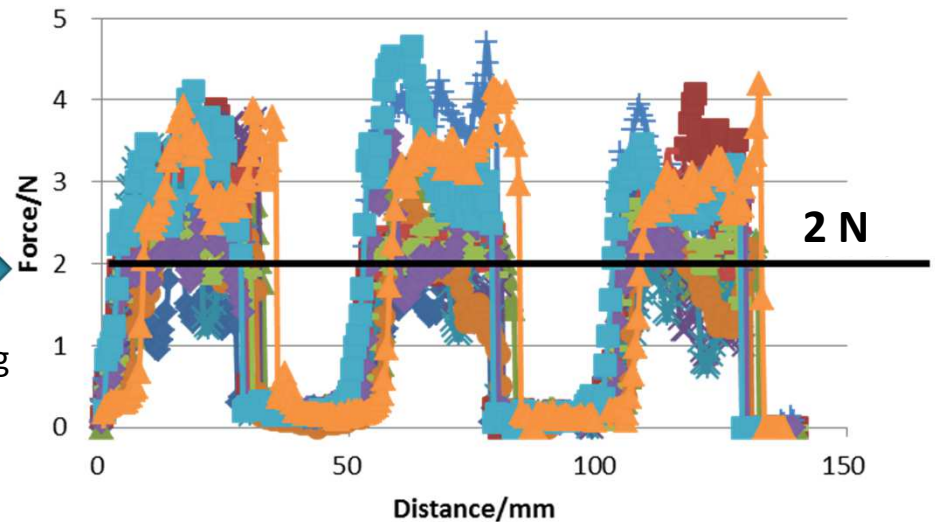
The peel strength of the fired paste depends on three aspects:



**Mechanical polishing**



Soldering



# Summary

## DuPont™ base metal paste for back tabbing

- Good printability of base metal paste
- Base metal survives thermal processing in **AIR**
- Base metal shows adequate conductivity
- Good adhesion to cell
- Good electrical contact
- Same cell efficiency
- “Solderable” using industry-acceptable processes
- High reliability and durability



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