Fraunhofer IWS Dresden

FRAUNHOFER-INSTITUT FÜR WERKSTOFF- UND STRAHLTECHNIK IWS

LINEAR PLASMA SOURCE

Surface functionalization, cleaning, coating, etching of metal, glass, plastics and semi-conductor material under atmospheric pressure

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Motivation

Plasma-chemical processes are often used to realize a wide variety of applications such as surface functionalization, cleaning, coating and etching. In order to process large-surface components and 3-dimensional components, industry demands a continuous scale up of the process technology. A compact and robust design is mandatory to integrate the source into existing processing lines using robots.

For this purpose, a linear plasma source with adjustable processing width for operation under atmospheric pressure was developed at Fraunhofer IWS Dresden. The LARGE-source guarantees a homogeneous processing of the substrate by the uniform plasma formation over the whole process zone (cover picture).

Advantages of the LARGE source are:
- compact design for easy integration into existing processing lines (Fig. 1)
- adjustable working width of up to 350 mm, combination of different plasma sources possible
- large variety of plasma gas mixtures like compressed air, N_2, mixtures of Ar and O_2, CO_2, N_2O, H_2, NH_3
- high plasma activity enabled by the use of the remote plasma
- use in air or under inert atmosphere (revolving gas technique)
- dynamic deposition rates for SiO_2 up to 200 nm m/min
- etching rate for silicon up to 600 nm/s

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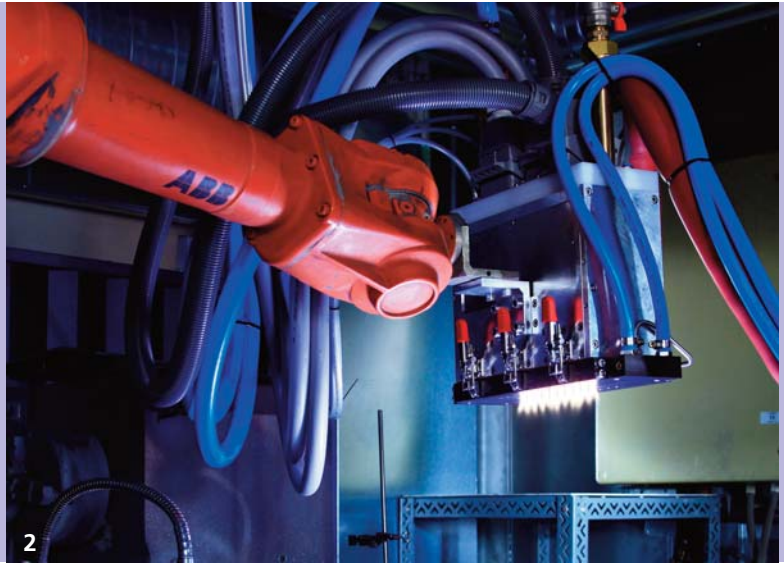
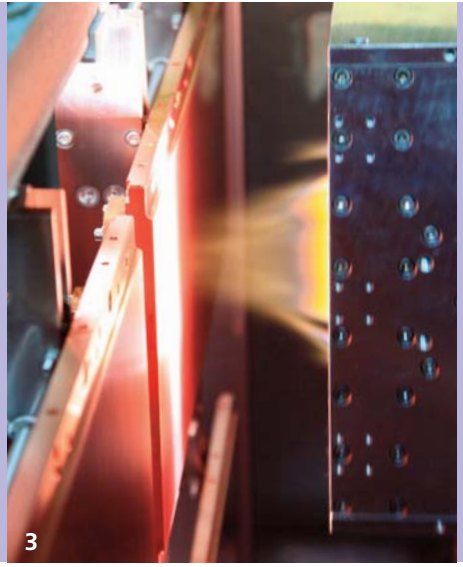




LARGE working principle

A direct current arc burns between two electrodes. A gas mixture evenly circulates around the arc perpendicular to the arc axis. The plasma gas flows through the plasma source at high speed and drives the excited activated species out of the source. These then transfer their energy to layer-forming precursors, etching gases or other reactive gases injected outside of the plasma source. The plasma torch temperature is determined by process gas, flow rate and working distance.

Mobile LARGE

In order to verify the feasibility of plasma technology for your application on site, Fraunhofer IWS Dresden provides a transportable 150-mm-LARGE plasma source including appendant peripheral devices.

Possible applications

Deposition of functional layers:
SiO_2, SiO_xC_y:H for enhanced scratch, wear and corrosion resistance, improves adhesion and reduces reflection. Deposition of the SiO_2 adhesion layer from 6 cm workings distance enables the coating of shaped devices with a 50 nm m/min deposition rate (200 nm m/min at 2 cm working distance)

Surface functionalization:
In case of polymers, the generation of functional groups on the substrate surface can be achieved by the combination of plasma gas mixture and precursor gas.

Plasma fine cleaning:
Processing is possible either by reducing atmosphere (forming gas, H_2, NH_3) or by oxidizing (O_2, CO_2, compressed air) e.g 0.05 - 0.1 mg/cm² oil-film on an aluminum foil, reduced at high process speed of 50 m/min.

Powder deposition:
Particles with a typical size of 10 nm to 50 µm can be deposited. A rate of 3.5 g/m² at 100 m/min feed rate could be demonstrated for, e.g., salts (50 µm).

Etching:
Si, SiO_2, ZnO, SiN_x can be etched with NF_3, SF_6, HCl with rates up to 600 nm/s (e.g. Si). Selective single-sided etching is possible.

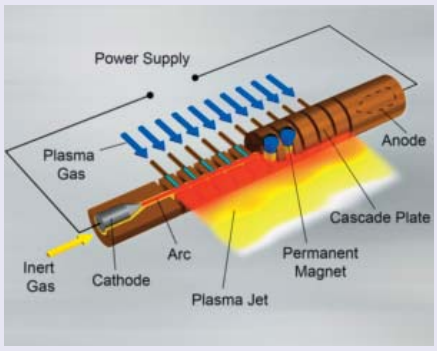
Cover picture
LARGE plasma flame with Ar+N_2 process gas

1 *150-mm-LARGE plasma source*

2 *LARGE-plasma source in combination with a precursor gas feeding system on a robot*

3 *LARGE plasma source on two dimensionally moving system for plasma fine treatment from copper*

Working principle of the LARGE-plasma source



Technical data

working width:	80 mm, 150 mm, 250 mm and 350 mm, due to customizable cascaded structure
size / weight:	280 x 115 x 360 mm³ / 16 kg (150-mm-LARGE)
power:	10 – 35 kW, depending on arc length and plasma gas mixture
activation principle:	DC-arc, thermal activation
plasma gas:	compressed air, N_2, mixtures of Ar and O_2, CO_2, N_2O, H_2, NH_3
remote precursor gases:	NF_3, SF_6, HCl
liquid precursors:	e.g. HMDSO and TEOS via carrier gas injection