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### A fixed arc length direct current plasma torch for reduced pressure deposition of thin films

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Because of its high energy density, direct current (dc) thermal plasmas are widely accepted as a processing medium which facilitates high processing rates, high fluxes of radical species, the potential for smaller installations, a wide choice of reactants, and high quench rates[1]. A broad range of industrial processing methods have been developed based on dc plasma technology. However, non-stationary features limited new applications of dc plasma in advanced processing, where reliability, reproducibility and precise controllability are required. These challenges call for better understanding of the arc and jet behavior over a wide range of generating parameters and a comprehensive control of every aspect of the plasma processing.

Plasma torch design is of the first phase in controlling the stability. Conventional self setting length arc torch usually has a drooping voltage-ampere characteristic (VAC) [2]. One of them is a high level of pulsations of arc voltage, especially at low currents, determined by large-scale shunting. In this paper, a fixed arc length dc plasma torch was further improved based on previous research, to produce stable and large volume plasma at reduced pressure.

A long channel with floating potential was inserted between the cathode and an abruptly expanded anode. The insert prevents the shortening of the arc with increasing current and elongates the arc length to obtain higher voltage at the same current level than that in free setting arc length torches. The VAC of the torch shows a U-shape curve. When the arc current is below 80 A, the arc voltage drops with arc current; when the arc current exceeds 80 A, an increase of arc voltage with arc current was observed. Pressure measurements in the cathode cavity showed that thermal choking occurred at the inter-electrode channel in most of the studied plasma generating parameters. The velocity of the plasma flow reaches the sound speed at the inter-electrode channel exit. However, because of the abruptly-expanded large diameter anode, the plasma jet is sub-sonic at the torch exit. With a further stabilized power source, time dependent fluctuation in arc voltage was controlled to be less than 6% at the worst condition. Using this torch, 20  $\mu$ m/s sintering deposition of uniform SiC film was achieved on 50×50 mm graphite substrate.

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#### References

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