White Paper for Frontiers of Plasma Science Panel

Date of Submission:	June 19th, 2015

Indicate the primary area this white paper addresses by placing "P" in right column.
Indicate secondary area or areas by placing "S" in right column

	"P", "S"
• Plasma Atomic physics and the interface with chemistry and biology	P
• Turbulence and transport	
• Interactions of plasmas and waves	
• Plasma self-organization	
• Statistical mechanics of plasmas	

Indicate type of presentation desired at Town Hall Meeting. (Note: I was able to change my schedule to attend the meeting. Please delete my previous submission. Thanks.)

	"X"
Oral	X
Poster	
Either Oral or Poster	
Will not attend	

Title:	**New forms of transient microplasma sources**
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- ***Research frontier***

Non-equilibrium plasmas at atmospheric and higher pressures are susceptible to instabilities and the glow-to-arc transition. Spatial confinement of the plasma to dimensions less than 1 mm and temporal excitation of the plasma with ultra-short (e.g. nanosecond) electric pulses are both promising approaches to produce stable glow discharges without arcing [1]. Nanosecond pulsed microplasma sources thus combine the advantages of both microplasmas in stability, scalability, and possible high energy density and pulsed discharges in enhanced efficiency, selectivity, and possible high power density.

Emerging forms of the transient microplasmas (with at least one dimension less than 1 mm) include guided-streamers (aka. plasma jets) [2, 3], surface-sliding discharges [4], and multiphase micro-discharges. These transient microplasmas challenge our basic understanding in plasma science and, in the mean time, provides new opportunities for a broad range of applications.

- ***Approach***

Fundamental studies including both experimental and modeling efforts would advance this fascinating field with new knowledge and discovery of new forms of transient microplasmas. Basic and advanced plasma diagnostics should be the primary research component and may include both electrical and advanced optical measurements to study the breakdown process, the transient energy-dependent electronic process, and the complex plasma chemistry for working in different gas compositions, flow-field conditions, as well as pressure and temperature parameters. However, the highly transient nature, the relatively low concentration of many of the interesting plasma species as well as the spatial limitation posed by the microscopic boundaries and dimensions all make the diagnostic task quite challenging. The

conventional tools such as Langmuir probe or optical emission spectroscopy with stark broadening become difficult or impossible to apply. In addition, the highly non-equilibrium nature of the electron energy distribution in these nanosecond high voltage pulsed discharges has made it difficult to use electron temperature to accurately describe the energy state of the plasma. Nevertheless, thanks to the recent advancement in pulsed power and laser technology and optics, successful examples of plasma diagnostics for investigating short-lived reactive plasma species can be found in measurements of ground state O [5] and OH [6, 7] in nanosecond pulsed plasma jets using advanced optical spectroscopy. Plasma dynamics and property studies with modeling are the other indispensible and nontrivial effort [8, 9] and need to couple closely with experimental parameters to understand the temporal and spatial challenges in the transient microplasmas.

• *Impact*

These new forms of transient microplasmas pose a wide range of applications from health care and medicine to industrial material fabrication, lighting, and environmental remediation. Fundamental studies of these plasmas will greatly benefit technology innovation in these applications.

In addition, these studies are inherently interdisciplinary since most of these potential applications stretch far beyond the traditional boundaries of plasma physics. Thus, many exciting discoveries can be anticipated due to both the ground-breaking nature of developing a thorough understanding these transient microplasmas as well as to the cross-pollination that would be driven by bringing together the requisite wide range of scientists, engineers, and medical practitioners.

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