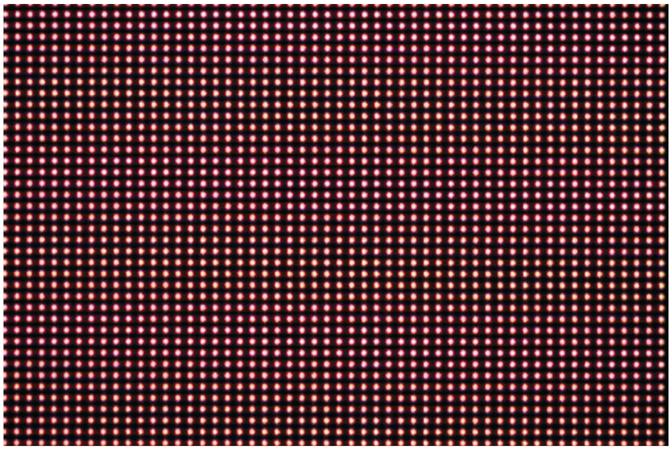

Fig. 2: A 500 x 500 array of microplasmas.

Plasma medicine is an emerging area of application, which has gained strongly in interest by the scientific community. Major advances were made possible by the development of plasma sources that are biocompatible (i.e. satisfy strict conditions in terms of their electrical, chemical, and thermal properties), consist of biocompatible materials, can generate copious amounts of reactive radicals and deliver them to biological tissue via plasma jets. We note that medical applications of plasmas also bear risks, which should be properly assessed [7]. Besides medical applications, studies on environmental applications have been performed (see e.g. Becker [8] and references therein). Lesser known, but important applications of microplasmas, are in the area of detectors [8] and even microthrusters [9].

Fig. 3: Atmospheric-pressure plasma jet interacting with human skin.

It should perhaps be noted that the rapid development of microplasma applications has often occurred by trial-and-error without having a good understanding of the underlying basic science. Plasma applications as diverse as surface modification and functionalization, light sources, ozone generation, pollution control, biological inactivation, sensors rely on the plasma-initiated generation of chemically reactive species, in particular reactive oxygen and nitrogen species. We only have an understanding of some of the key plasma chemical reaction pathways that drive the process in a few applications. Moreover, in almost all areas of application there is a lack a detailed knowledge of the coupling of the plasma physics to the plasma chemistry. Researchers do not yet have the level of understanding of the basic plasma physics that will allow precise tailoring of the plasma parameters such as plasma composition and gas temperature, power density, electron density, and electron energy distribution to selectively maximize the generation of certain plasma species, while minimizing or suppressing the formation of others. Thus, there is a lack of ability to achieve full control of the plasma chemistry in many applications by making use of insight into the basic plasma physics.

That said, applications can also be powerful drivers and motivators for basic science and the development of new plasma sources. As an example, demands for plasma sources with very application–specific operating parameters and performance characteristics led to the development of a wide range of microplasma sources [1] starting with the original concepts of a microplasma generated between parallel-plate electrodes that included dc microplasmas between a flat cathode and a ring-shaped electrode (so-called cathode boundary layer plasmas), and ac (microwave) microdischarges between parallel edge electrodes. Very quickly, the need arose for generating and sustaining microplasmas in two-dimensional microcavity electrode structures excited by dc, ac, and pulsed power. By now, various microplasma arrays are being used with arrangements where the individual microplasma are operated in series or in parallel.

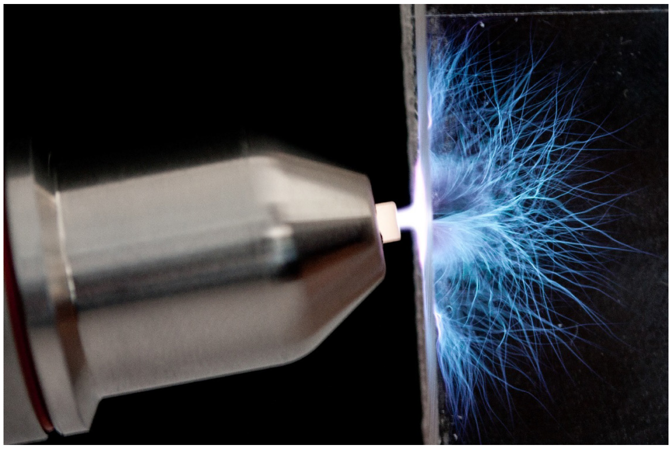

Fig. 4: Atmospheric-pressure plasma jet generating microplasmas on the opposite side of a surface.

The need for plasma treatment of objects, whose size and shape did not allow them to be placed in the microplasma gaps for direct place treatment but rather required remote plasma treatment, led to the advent of various types of atmospheric-pressure plasma jets (APPJs) [10]. APPJs have gained wide spread use in the past 10 years. In the rapidly developing field of plasma medicine, the excitement stemming from successful applications such as seeing how the use of a microplasma can accelerate blood coagulation or stimulate wound healing has triggered many studies into identifying the underlying chemical and biological reaction pathways initiated by the plasma.

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