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The complex physics of pulsed and level-to-level discharges

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While they are widely used, plasmas are not the "perfect" processing technology, particularly as critical device dimensions have shrunk. As long as two decades ago, it was understood that there were a number of mechanisms via which plasmas might induce damage on a device. For a multitude of reasons, pulsed and level-to-level plasmas have often been considered the most viable processing technology for overcoming the limitations of continuous wave processing. However, the combination of pulse rate, duty factor, power levels, gas species, flow rate and pressure, provides one with an almost endless free parameter space. This makes finding a set of "ideal" parameters difficult at best. For example, the plasma will 'extinguish' under some fully pulsed conditions while under other very similar conditions it will not 'extinguish'. This leads to very different restart during the plasma on portion of the pulse, 're-ignition' vs 're-energization'. In 're-energization', plasma sheaths will exist prior to the reapplication of power – while in 're-ignition' the sheaths need to be reestablished. This subtle, yet significant, difference changes how power is initially deposited into the system. Such knowledge is critical in helping the general low-temperature plasma community establish guidelines for optimizing the use of pulsed and level-to-level discharges in industrially relevant processing conditions. In this talk, we will examine what is known about such systems and how that might impact the use of pulsed and level-to-level discharges. This work is supported by the National Science Foundation under Grant No. NSF IIP1338917. In addition, support from the industrial partners to the I/UCRC for Laser and Plasma Advanced Manufacturing, specifically Applied Materials and Lam Research.