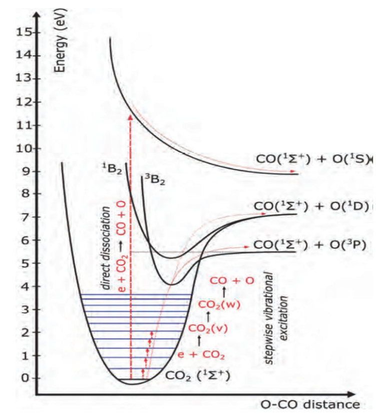
POTENTIAL OF ELECTRON BEAM SUSTAINED HYBRID PLASMAS FOR POWER-TO-X PROCESSES: AN OUTLOOK

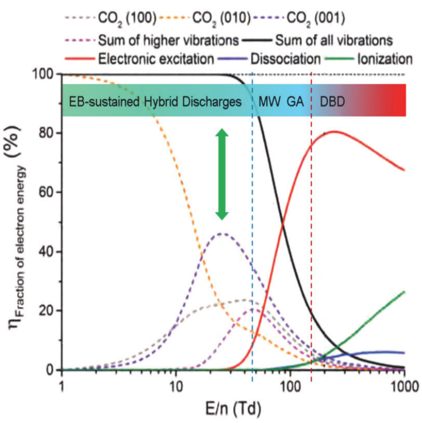
David Schreuder, Lars Dincklage, Burkhard Zimmermann,
Ralf Blüthner, Björn Meyer, Gösta Mattausch
Fraunhofer Institute for Organic Electronics, Electron Beam and Plasma Technology FEP,
Winterbergstraße 28, 01277 Dresden, Germany
Email: David.Schreuder@fep.fraunhofer.de

ABSTRACT

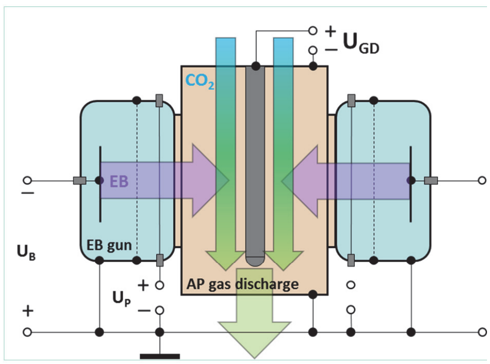
Research in Power-to-X technologies is motivated by their potential of converting electrical energy from fluctuating renewable sources into high-density, easy-to-store and loss-free transportable chemical energy storage media for the seasonal balance of supply and demand. Ideally, processes would be developed which also facilitate the defossilization of the transport sector and basic industries by efficient synthesis of green fuels and chemical raw materials utilizing CO_2 as carbon source. Non-thermal plasma-chemical methods are widely investigated for this purpose because they are comparably easy to scale, flexible concerning the conversion pathways, and highly efficient in molecular dissociation through vibrational excitation (fig. 1) [1]. In this context, commonly applied self-sustained discharges are generally limited by a trade-off between energy efficiency and conversion degree since the applied electric fields insufficiently promote simultaneous ionization (> 10 eV) and vibrational excitation (< 0.4 eV) (fig. 2) [1]. In non-self-sustained discharges, however, these mechanisms can be tuned independently by separate energy sources. Moreover, they permit energy-efficient non-equilibrium reaction conditions and are less susceptible to plasma instabilities [2]. The benefits of this approach have been experimentally verified on laboratory scale in previous work [3]. At Fraunhofer FEP, such hybrid plasmas shall be demonstrated on pilot scale by combining electron beams for external ionization with low-field gas discharges to selectively stimulate vibrational excitations (fig. 2). Industrially suitable processes call for reactions at atmospheric pressure. This means, the electrons provided by the gun must be injected into an elevated-pressure plasma reactor. Two different methods are applied and currently investigated for this purpose: Thin metal foils (Lenard windows) in combination with a wide-area toroidal EB source (fig. 3) and differentially pumped pressure stages with orifices for the transfer of axial beams of high power density.



➤ Fig. 1: Efficient dissociation by „ladder climbing“



➤ Fig. 2: Selective energy transfer to vibrational modes



➤ Fig. 3: Setup for electron beam sustained gas discharges

References

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