理化所新型热声发电技术研究取得进展

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外燃式发动机具有不受热源种类限制的特点，可以利用太阳能、生物质燃烧热、工业余热等热源，近年来备受关注。热声发动机作为一种外燃式发动机，具有结构简单、可靠性高、使用寿命长、环境友好等突出优点。热声发动机可以将外部热量转化为声功输出，产生的声功可用来驱动声电转换装置从而构成热声发电系统。目前应用于热声发电系统中的声电转换装置主要包括直线发电机、压电换能器、双向透平等。由于现有热声发电系统中声电转换装置存在固有局限性（包括结构复杂、成本高、可靠性低等），因此有必要探索具有结构简单、成本低廉、可靠性高等优势的声电转换装置。

摩擦纳米发电机（Triboelectric nanogenerator, TENG）通过摩擦起电和静电感应可将多种形式机械能有效转化为电能输出，其潜在应用领域包括微纳能源、自驱动传感、蓝色能源和高压电源等。目前大多数摩擦纳米发电机的研究局限于环境中随机机械能的收集和转换，限制了其应用范围。热声发动机可将外部热源的热能转换成声能（声波形式机械能），从而为摩擦纳米发电机提供稳定而持续的机械能。2017年，中国科学院理化技术研究所研究员罗二仓课题组提出“热声驱动摩擦纳米发电机”这一热-声-电换能新流程，并通过将一接触-分离模式摩擦纳米发电机耦合在驻波热声发动机谐振管末端，实验验证了摩擦纳米发电机作为声电转换装置应用于热声发电系统中的可行性（*Applied Physics Letters* 2017;111(15):153901）。

基于此，该课题组近期提出将液态金属基摩擦纳米发电机（LM-TENG）耦合在驻波型气-液谐振热声发动机谐振管中，从而构建出一种完全无固体运动部件的高可靠的热声发电系统。该发电系统的工作原理为：热声发动机利用热致声效应将外部热源的热能转化为工作气体往复振荡的声能，气体的往复振荡驱动U形谐振管中的液态金属液面做升降往复运动，使得摩擦纳米发电机中两种摩擦电性质不同的材料（液态金属和摩擦材料）表面周期性接触和分离，利用两种材料之间摩擦/接触起电产生的电荷分离和感应电荷产生的电势差驱动外接电路中自由电子流动，进而将驱动两种材料接触分离的声能收集起来并转化成电能输出，最终实现从热能到电能的持续、稳定转换。实验中，热声驱动液态金属基摩擦纳米发电机获得了最高15
V的开路电压输出，验证了这一新型热声发电技术的原理可行性。

相关研究成果以*Thermoacoustically driven liquid-metal-based triboelectric nanogenerator: A thermal power generator without solid moving parts*为题，在线发表在*Applied Physics Letters*上，并被选为Featured Article。理化所罗二仓和研究员余国瑶为论文通讯作者，特别研究助理朱顺敏为论文第一作者，中科院北京纳米能源与系统研究所研究员唐伟对该工作的实验设计提供了指导。上述研究工作得到国家重点研发计划和国家自然科学基金的资助。

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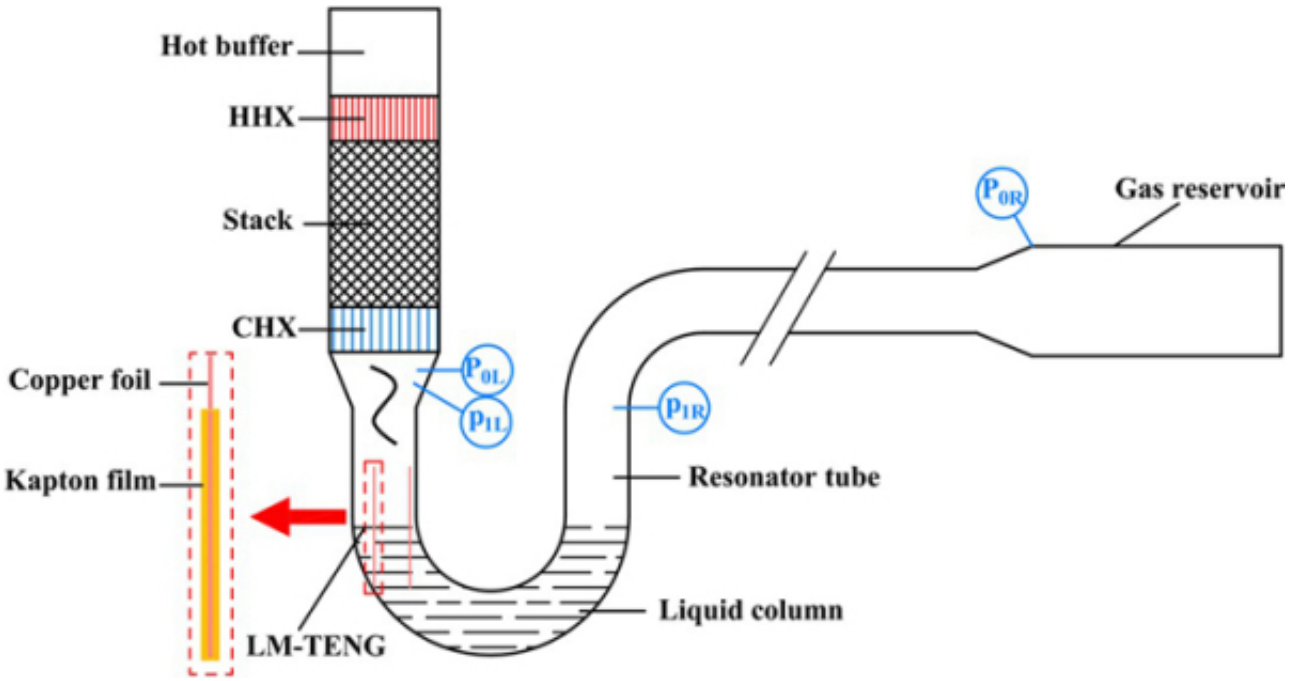

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