Title:	Polaritronics with 2D Materials
Authors:	Bhatt, Pooja
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Abstract:	Tailoring material properties has a tremendous implication for realizing better functional devices. Structural and composition variations are the conventional strategy used to achieve this goal. Very recently, strong light-matter coupling was introduced as an unconventional technique to modify the properties of materials. 1 Hybrid light-matter states are generated if the exciton transition of material and the electromagnetic mode frequency of confined field are in resonance. These new eigenstates are called polaritonic states having quasi-Bosonic nature. 2 The study of the optoelectronic properties of polaritonic states is called polaritronics. 3 The current thesis focuses on polaritronics of transition metal dichalcogenide based 2D materials in a Fabry-Perot (FP) cavity. Both optical and electrical studies of WS 2 coupled in a cavity show intriguing characteristics of polaritonic states at room temperature. Our studies suggest that the effective mass of the polaritonic states reduced drastically under strong coupling. 4 Further, we combined a metal oxide semiconductor field effect transistor (MOSFET) with an FP cavity and studied both the optical and electrical signatures. Electron transport mobility was enhanced up to fifty times under ON-resonance conditions. Our analysis suggests that the electronic band structure of WS 2 can be tailored precisely by strong light-matter coupling. 5 Further, the photoresponsivity of donor-acceptor pairs containing MoS 2 monolayer as a donor and a J-aggregate dye as an acceptor were also studied under strongly coupled conditions. Long-range energy transfer (beyond Förster distance) can be achieved at ON-resonance conditions. 6 These studies suggest that vacuum engineering of materials is possible without chemical and physical modification. Our finding can have potential applications in optoelectronics to realize polaritonic devices at room temperature. References: 1. 2. 3. 4. 5. 6. E. Orgiu, J. George, J. A. Hutchison, E. Devaux, J. F. Dayen, B. Doudin, F. Stellacci, C. Genet, J. Schachenmayer, C. Genes, G. Pupillo, P. Samori, T. W. Ebbesen, Nat. Mater. 2015, 14, 1123. T. W. Ebbesen, Acc. Chem. Res. 2016, 49, 2403. B. Deveaud-Plédran, Nature 2008, 453, 297-298. Bhatt, P.; Dutta, J.; George, J., Electromagnetic Field Dependence of Strong Coupling in WS 2 Monolayers. physica status solidi (RRL)–Rapid Research Letters 2021, 15 (4), 2000580. Bhatt, P.; Kaur, K.; George, J., Enhanced Charge Transport in Two-Dimensional Materials through Light– Matter Strong Coupling. ACS Nano 2021, 15 (8), 13616-13622. Bhatt, P.; Dutta, J.; Kaur, K.; George, J., Beyond Förster Distance Energy Transfer in Strongly Coupled Donor- Acceptor Phototransistors. (Manuscript under review).
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