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WHAT MATERIAL TO PLACE WHERE?

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Abstract. Designing high-performance parts increasingly requires not just choosing a shape, but also tailoring what material goes where inside that shape. Additive manufacturing technologies are making such spatial control of material properties more and more feasible, opening the door to designs that were once impossible. Yet the palette of materials typically available to designers is limited and fixed, while the full range of conceivable materials is vast—and often uncertain. This raises a fundamental challenge: how do we optimize a part's material distribution when many of the materials that might be ideal do not yet exist, or their feasibility is unknown? In this talk, we frame material properties themselves as design variables, co-optimizing their spatial distribution together with the part's performance objectives. The key difficulty is constraining this search to materials that are actually possible. We address this through a feasibility function that quantifies the likelihood that a given combination of material properties can be realized, enabling designers to balance ambition against risk. This strategy makes it possible to explore ambitious design spaces—such as graded or hybrid materials—while still grounding the results in manufacturable reality. We illustrate the approach through examples in mechanical and thermal design, showing how feasibility-guided optimization produces new insights into "what material to place where."

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