



NOW FOR SOMETHING COMPLETELY DIFFERENT

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PAST IS PROLOGUE

- UoM
 - Accidental tourist in the metalcasting field,
- General Motors
 - Industrial production of gray iron cylinder blocks and heads,
- TRW Turbine Components Div (now PCC Airfoil)
 - Commercialization of the Single Casting process,
- Atmosphere Group / Applied Process Inc.
 - Commercialization of the Austempered Ductile Iron (ADI) process.

IRON TYPES / TENSILE STRENGTH

Gray Iron

20ksi-40ksi TS

(140-275 MPa)

Compacted

Graphite Iron

40ksi-60ksi TS

(275-400 MPa)

Malleable Iron

60ksi-105ksi TS

(400-725MPa)

Ductile Iron

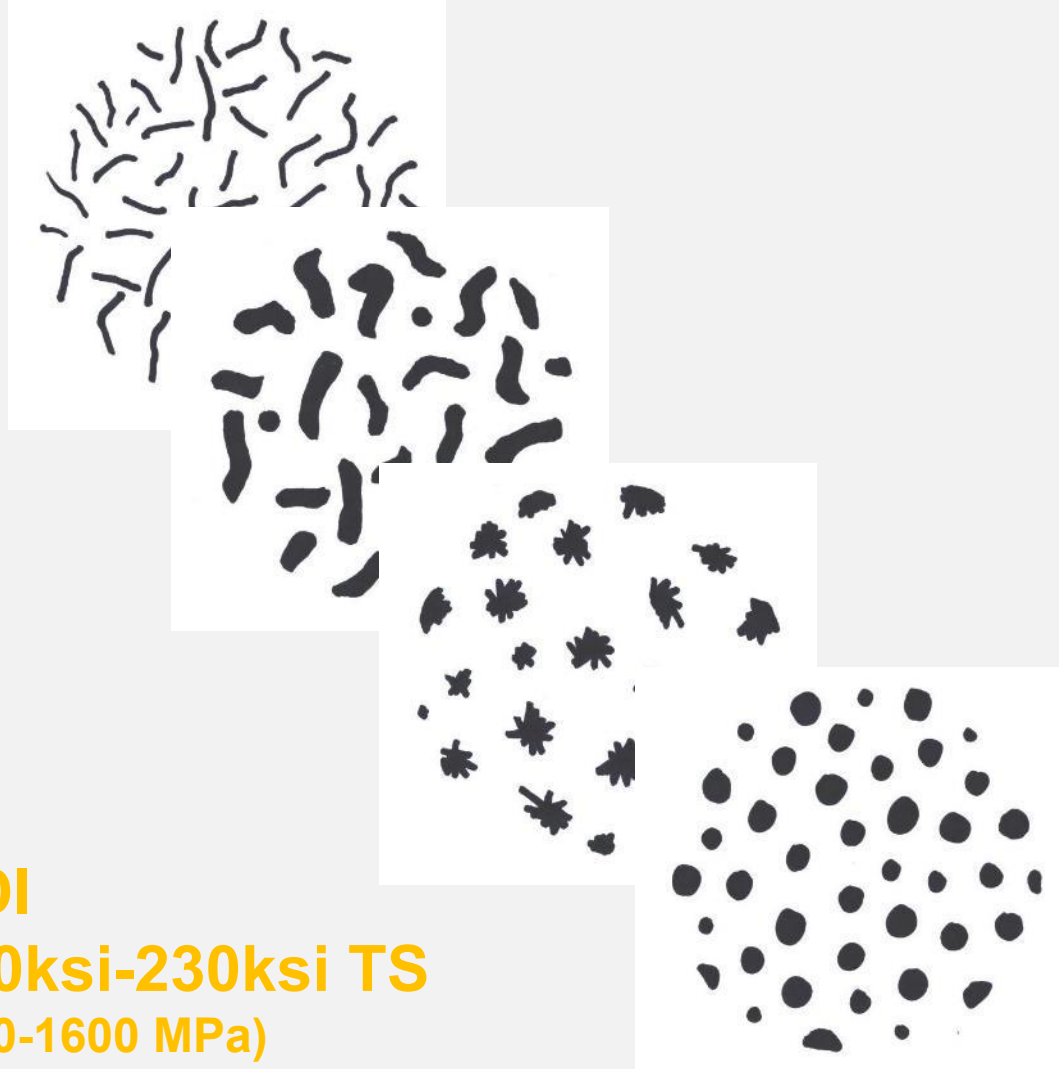
60ksi-120ksi TS

(400-825 MPa)

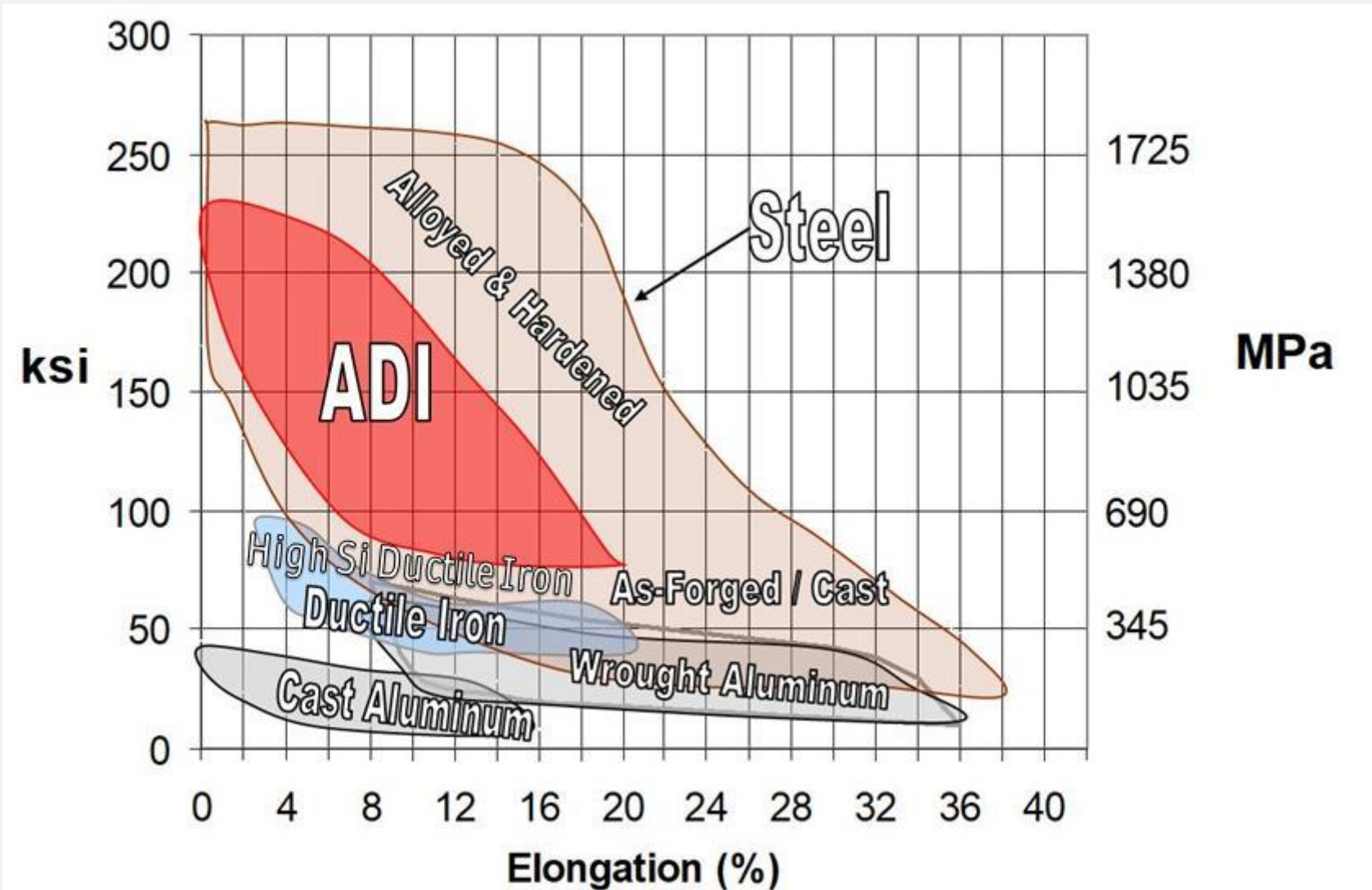
ADI

110ksi-230ksi TS

(750-1600 MPa)

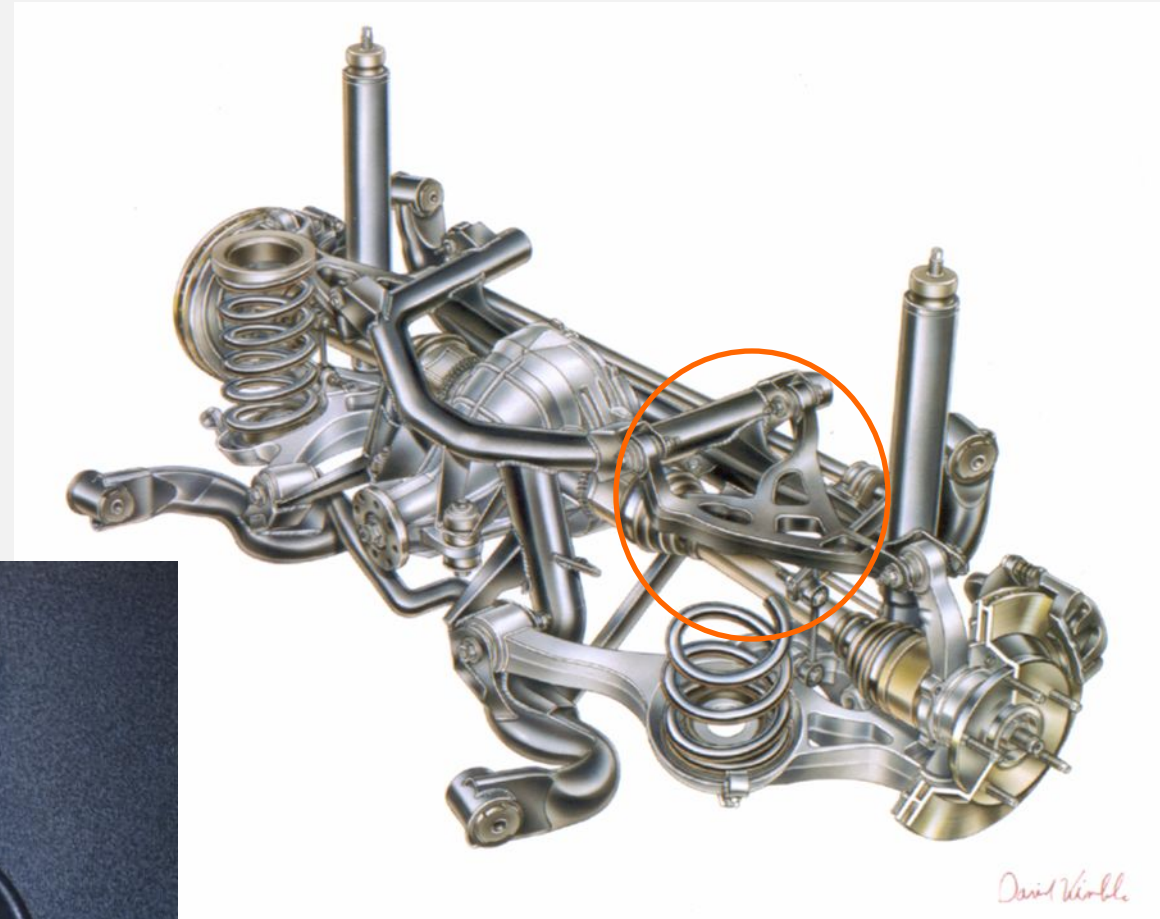


YS VS ELONGATION FOR VARIOUS MATERIALS



ADI SUSPENSION UPPER CONTROL ARM

This 3.4kg ADI upper-rear suspension arm replaced an aluminum design that would not fit in the sports-car package.





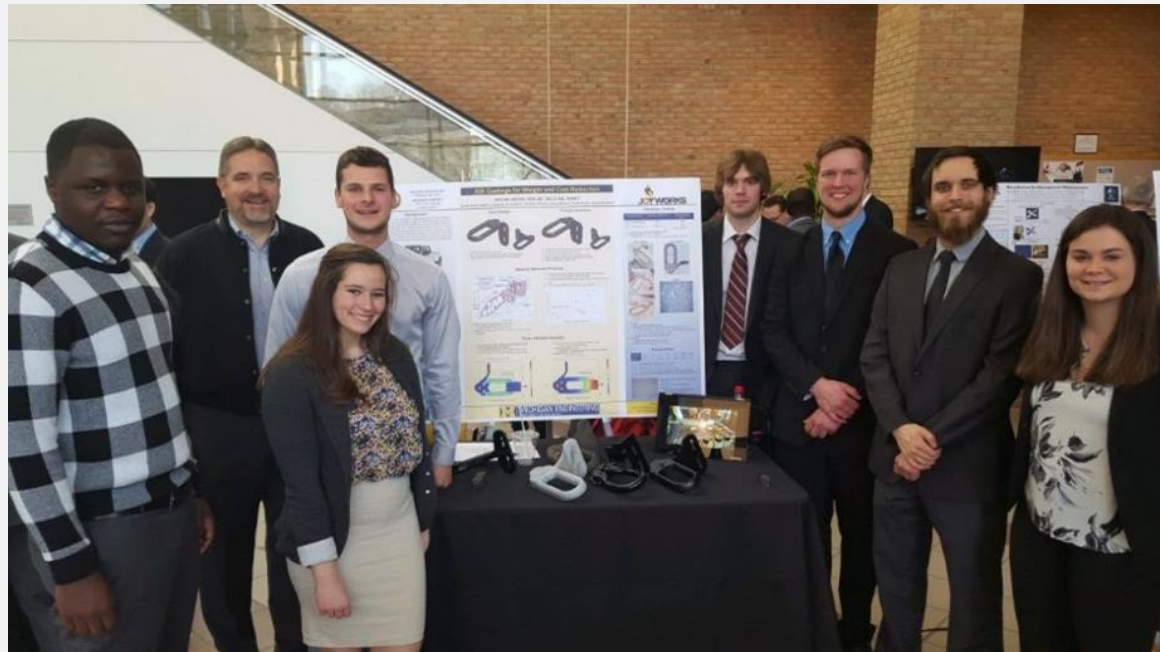
Joyworks Studio - Ann Arbor, Michigan





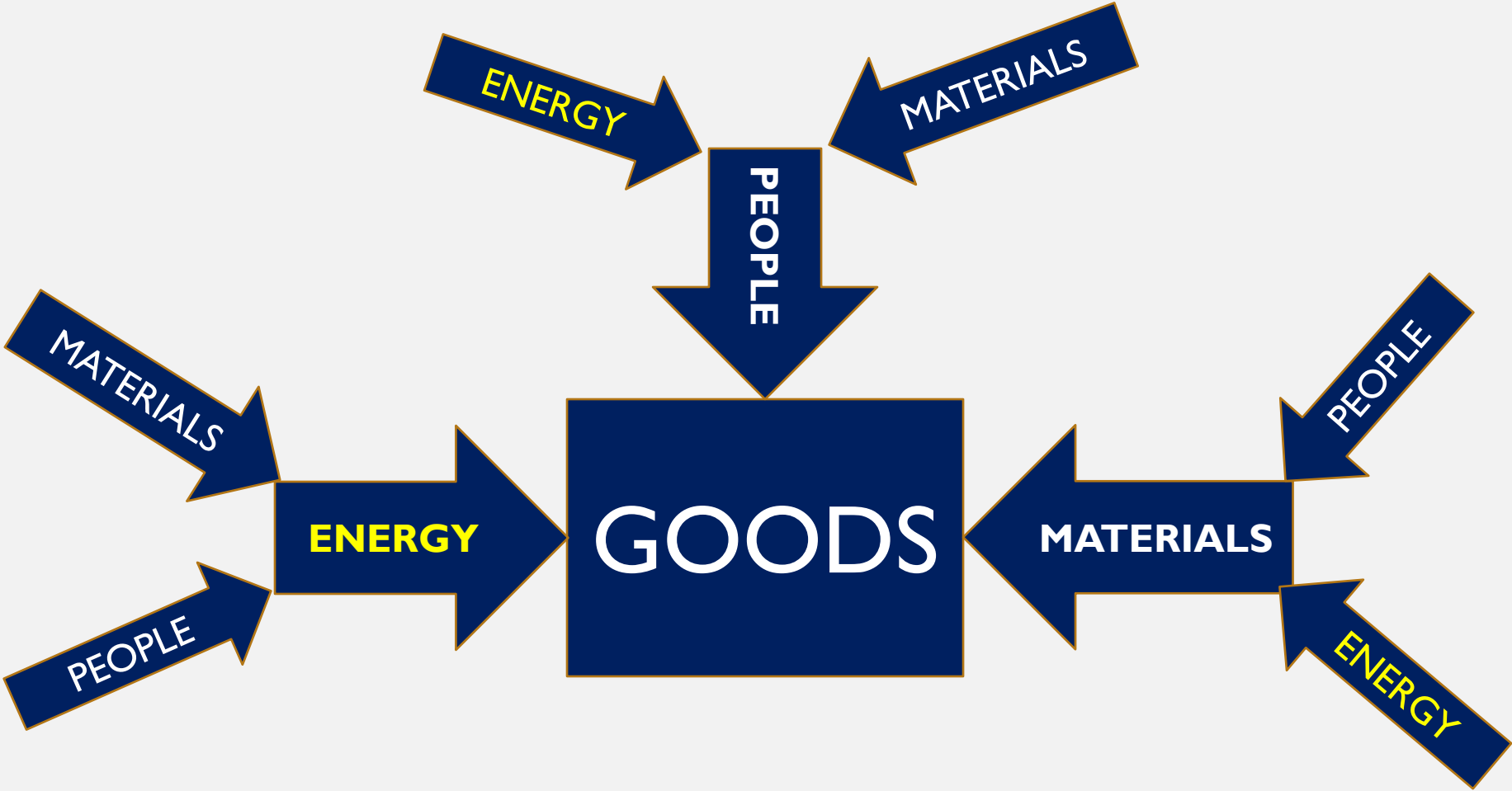


PIZZA AND POUR, MSE 365, ENG490



REVELATIONS

- ADI has superior properties to competitive material/process combinations, but process limitations prevent manufacturers from exploiting them,
- Casting is the lowest energy manufacturing path from metallic ores to metal product,
- Energy is 50% of the cost of goods,
- Embodied energy in a thing is directly proportional to price,



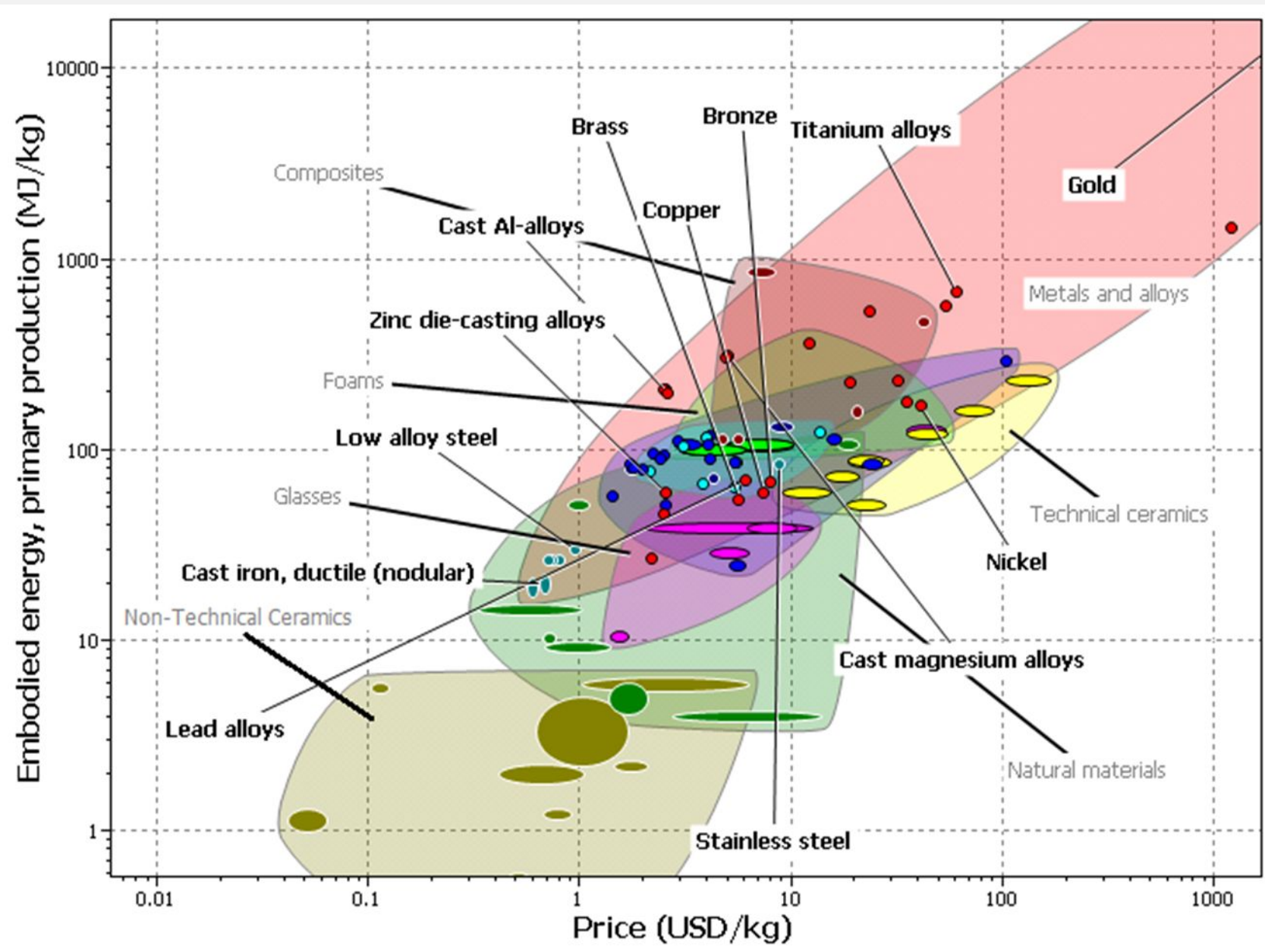
GOODS

Generally consist of about:

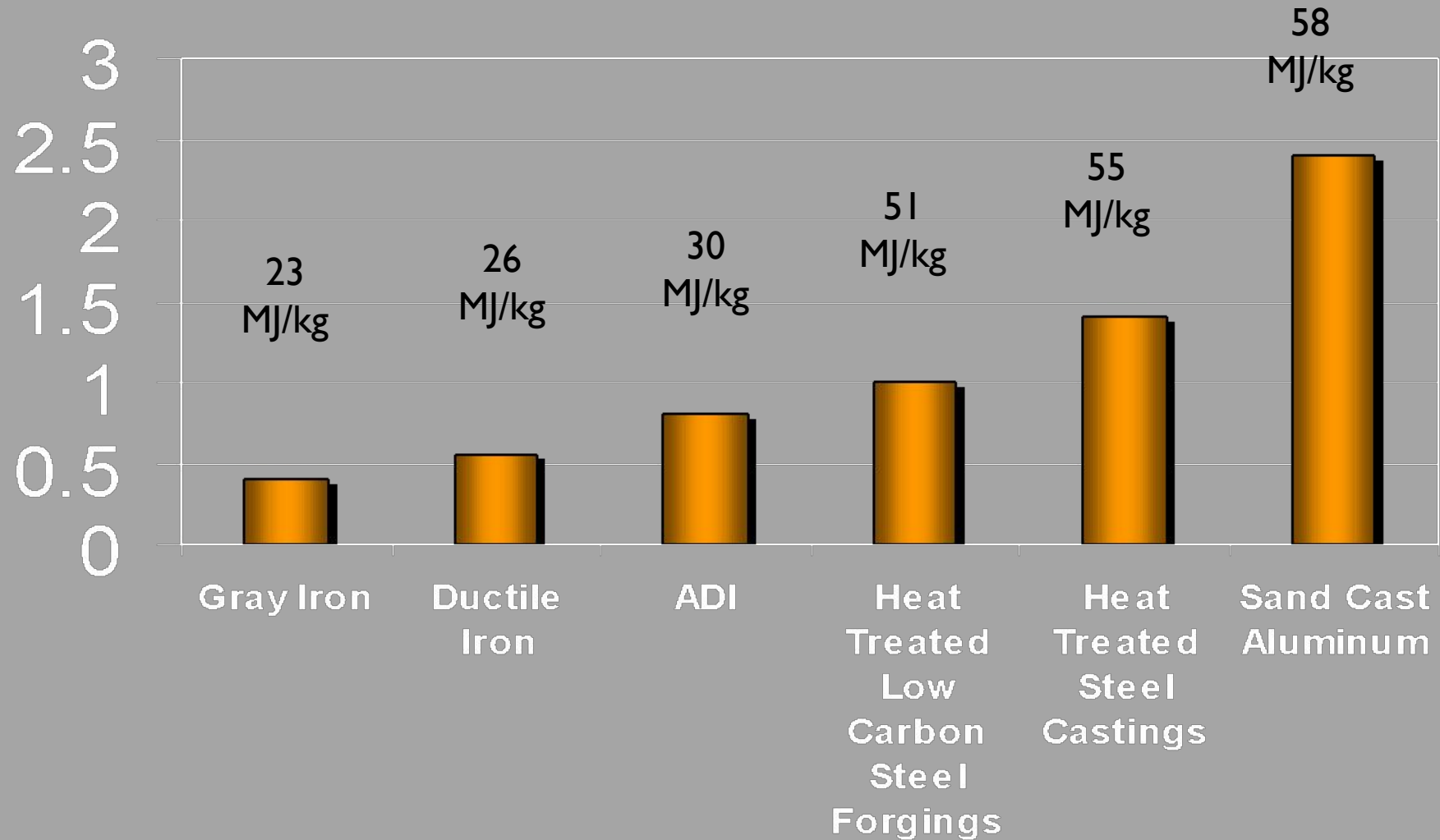
25% People

25% Materials

50% **Energy**



Relative Cost per Unit of Mass



EMBODIED ENERGY

Material	MJ/kg
Wrought Aluminum Sheet (Primary, average)	255
Copper (average)	151
Structural Polymers (Primary, average)	84
Magnesium (average)	80
Stainless Steels (average)	79
Rubber (average)	70
Cast Aluminum (Primary, average)	58
Plain Carbon and Low Alloy Steels (average)	51
Structural Polymers (secondary, average)	42
Malleable Iron (average)	35
Glass (Primary, average)	30
Austempered Ductile Iron (ADI) (average)	30
Ductile Iron / CG Iron (average)	26
Cast Aluminum (secondary, average)	23
Gray Iron (average)	23

BARRIERS TO LIGHTWEIGHT DUCTILE IRON AND ADI CASTINGS

- Need 3mm sections- commercial producers are loathe to go below 5mm,
- Hard tooling required,
- Draft required,
- Undercuts and multiple-plane designs require cores...and more tooling,
- Carbides in thin sections are detrimental to material properties,
- Metal fluidity must be sufficient to run thin sections with gravity pouring.

WHAT ABOUT ADDITIVE MANUFACTURING?

- Direct metal printing is incredibly slow and energy intensive,
- Printed polymeric patterns are already well utilized in metalcasting,
 - Printed “waxes” for investment castings,
 - Printed patterns/pattern inserts for sand casting molding,
- Why not printed molds and cores?

BARRIERS TO COMMERCIALIZATION OF PARTICLE-BED ADDITIVE MANUFACTURING

- Incumbent particle-bed printers:
 - Are Slow,
 - Are Expensive,
 - Require user to buy expensive, pre-coated sand,
 - Cannot use reclaimed sand,
 - Use petrochemical binders that emit significant VOC's during metalcasting.

THE PATH TO COMMERCIALIZATION OF A SAND MOLD AND CORE ADDITIVE MANUFACTURING DEVICE

- An order of magnitude cheaper,
- An order of magnitude faster,
- Capable of using a range of un-coated particulates,
- Capable of using a range of binder systems,
- Capable of using reclaimed particulates.



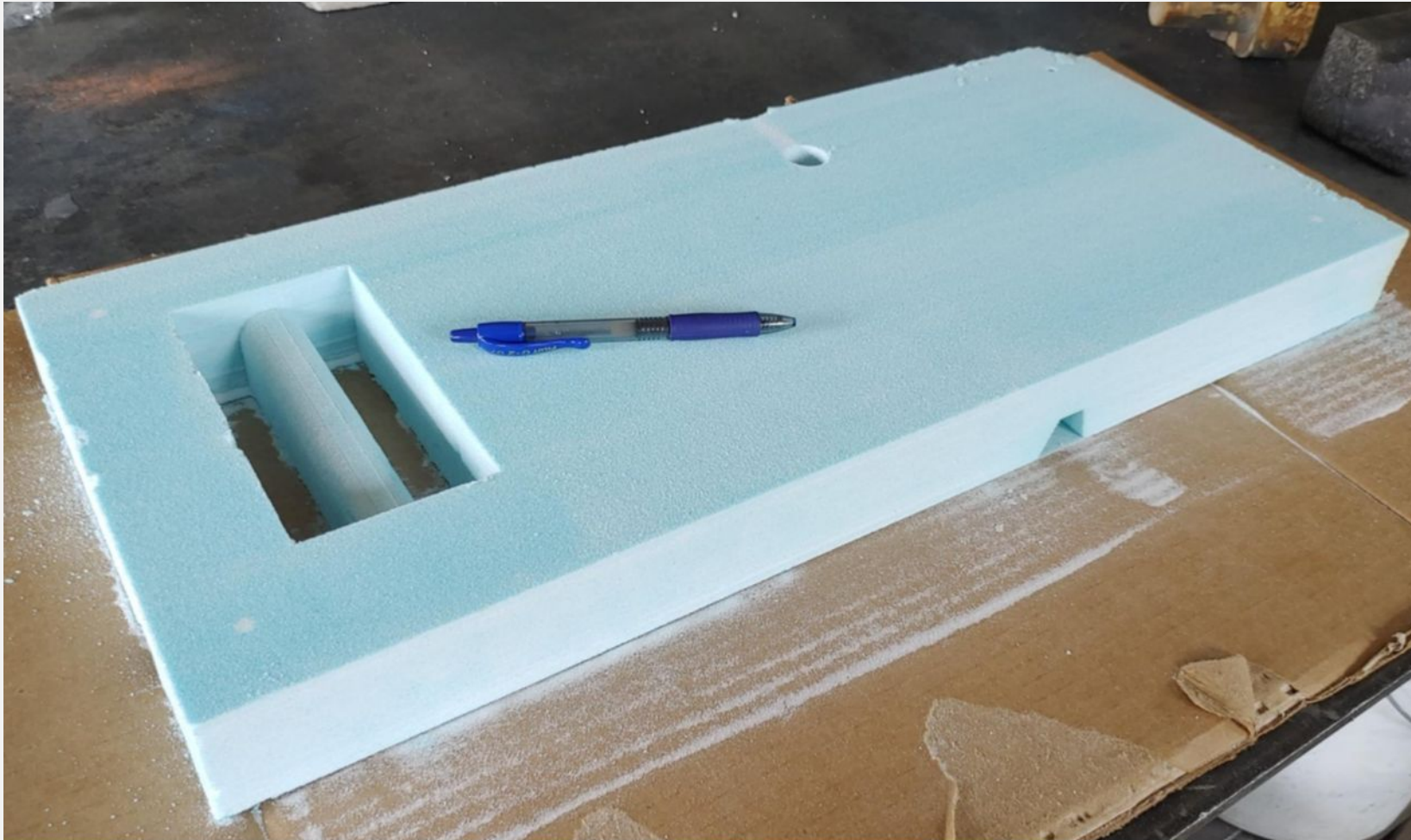
LIGHTSPEED CONCEPTS

IRV-BUILDER

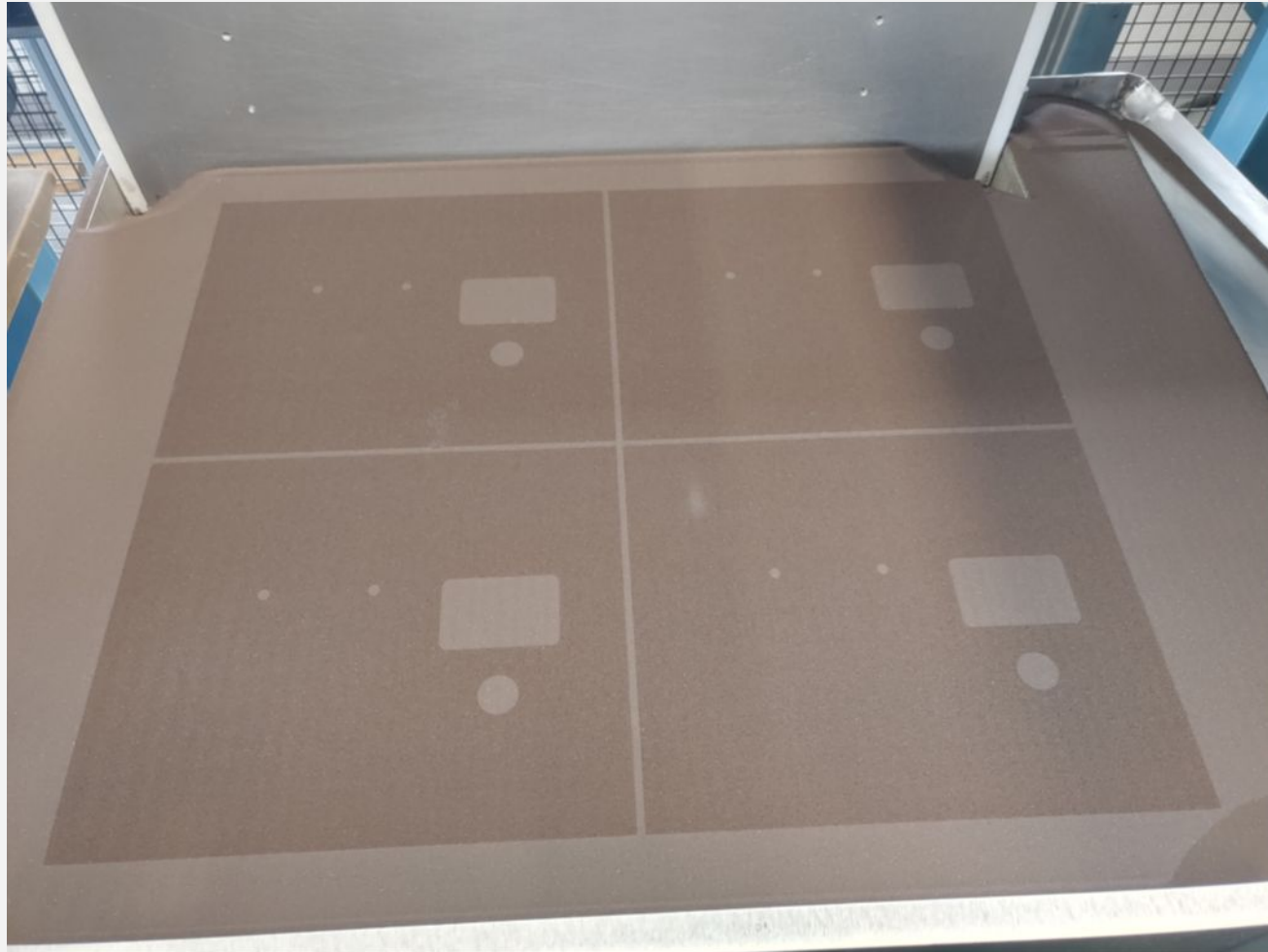
BLUENANO

All Michigan, private, capital and manufacturing partners.
Subcontract substantial development work to Joyworks.

EARLY V-BUILT SLAB BLUENANO CAPABILITY STUDY



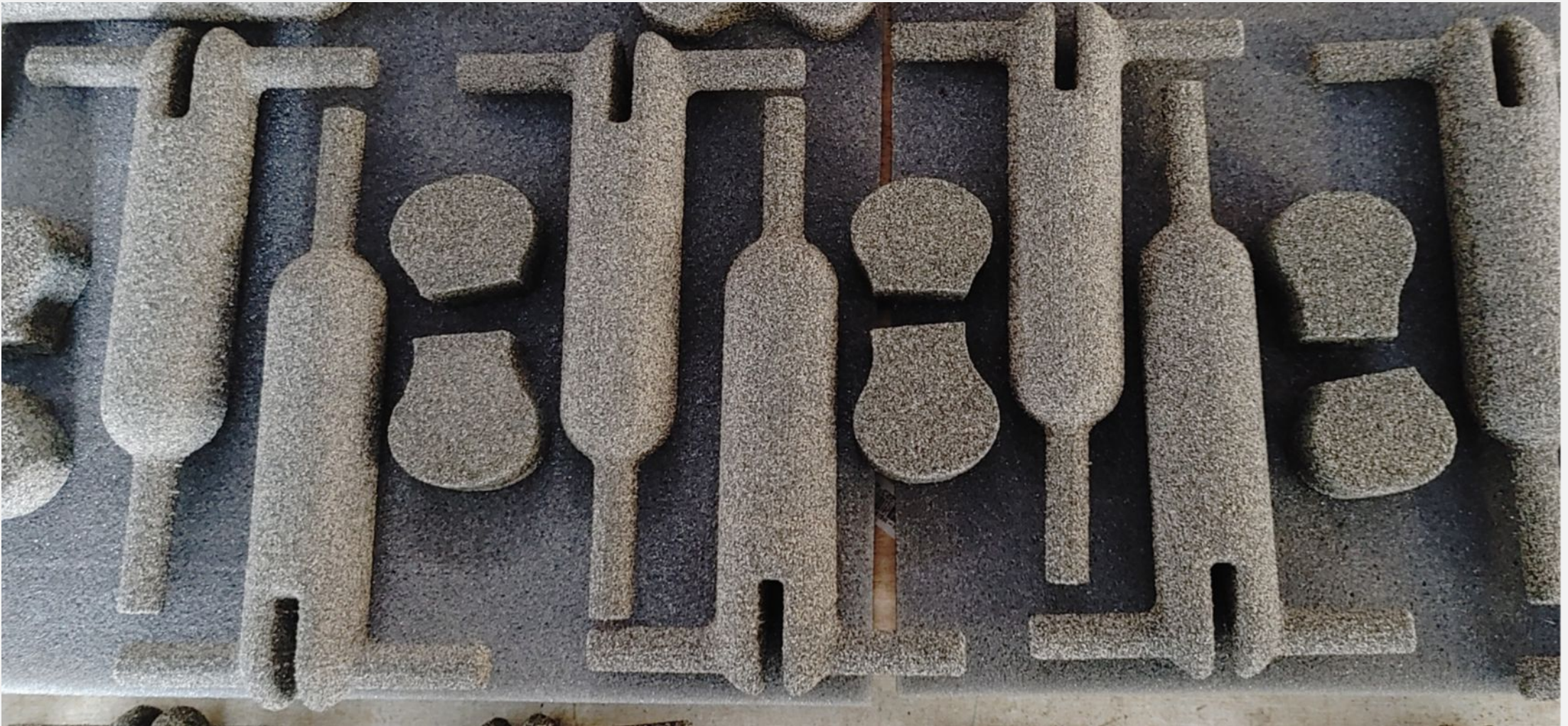
ALPHA IR V-BUILDER BED



V-BUILT LETTERING NO DRAFT



V-BUILT CORES & TEST BARS
BLUENANO BINDER / RECLAIMED SAND



3MM THICK ADI TEST FINGER CASTING
1250MPA TENSILE, 14% ELONGATION
BENT AROUND VICE FACE

