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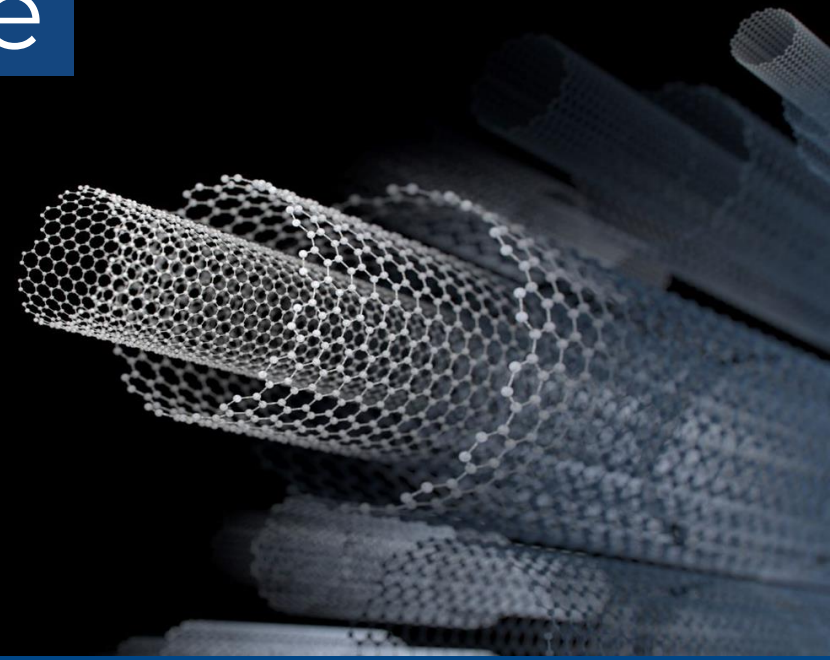
San Diego State
University

Graphene Dynamics: Shaping Sustainable Concrete Solutions

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THE WORLD'S GATHERING PLACE FOR ADVANCING CONCRETE



Outline

1 WHAT is Graphene?

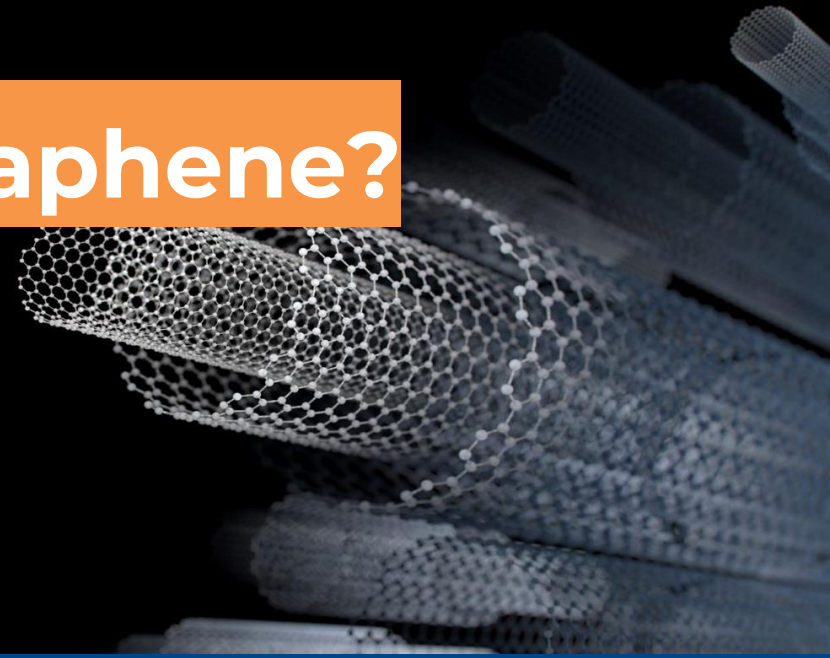
2 HOW can graphene help achieve feats
in concrete sustainability

3 WHERE does the concrete industry
stand with graphene?

4 WHEN can we see change?



WHAT is graphene?

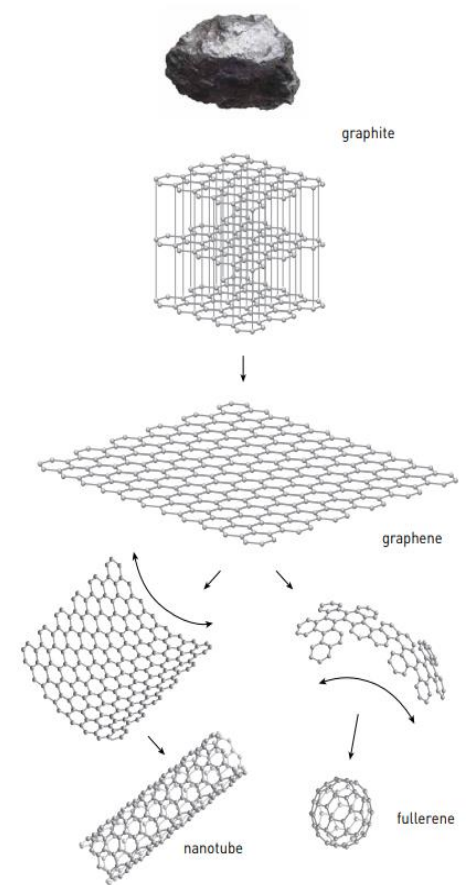




WHAT is graphene? Background

GRAPHENE IS...

- The world's first isolated 2D nanomaterial
- An allotrope of carbon
- The thinnest material
- The strongest material
- The most conductive material



(Salami, B. A., et al., 2023)



WHAT is graphene? Background

HISTORY

- First discovered by Professors Andre Geim & Konstantin Novoselov at The University of Manchester in 2004 [2]
- First isolated from graphite by using sticky tape (Mechanical Exfoliation) [2]



The Nobel Prize Winners in Physics 2010



Andre Geim

Konstantin Novoselov





HOW can graphene help achieve feats in concrete sustainability?

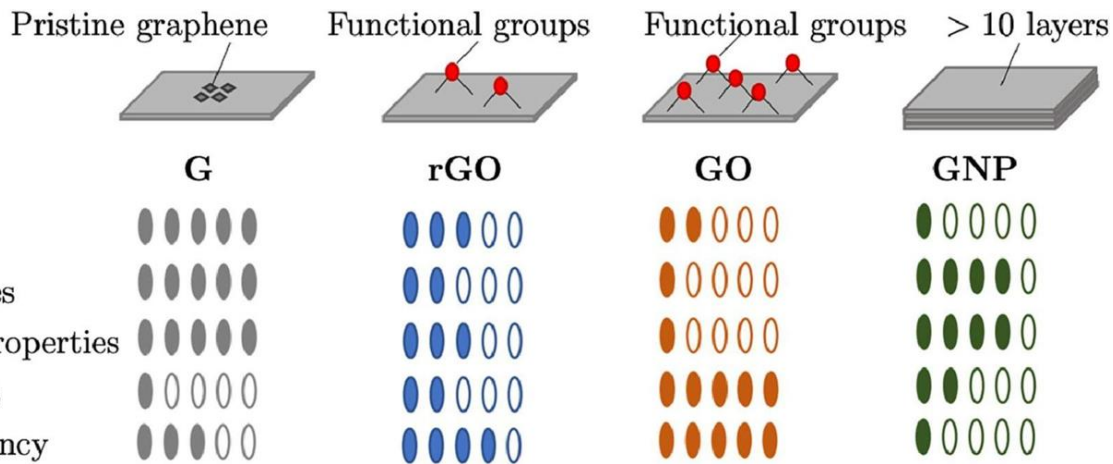




HOW can graphene help achieve feats in concrete sustainability?

Variety & Flexibility

- Graphene can come in various shape or form, with varying levels of mechanical or thermal properties.
- Forms of graphene will have varying dispersibility in cementitious products



What form of graphene should be used?

(Salami, B. A., et al., 2023)



Graphene & Concrete

Current literature suggests that graphene in its various forms may be utilized to address

- low tensile strength
- permeability
- brittleness
- Acid and sulfate resistance

The implementation of graphene may contribute to

- Reinforcement at a nano-scale
- lighter concrete
- thermal conductivity
- improved flexural strength
- Enhanced Thermal stability

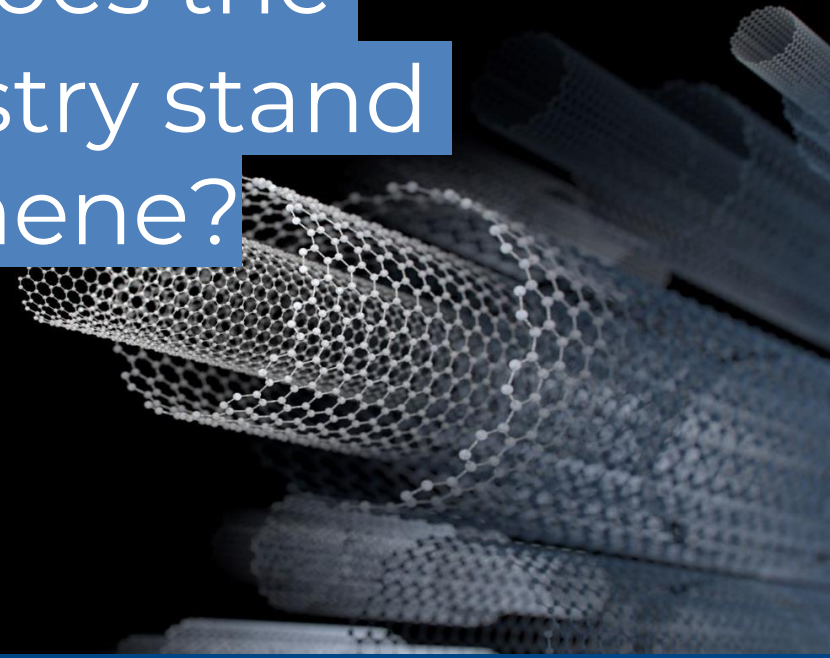
graphene may reduce the need for reinforcing steel [1], cement, and sand [3]

2%

Reduction in total global carbon emissions with the use of graphene as reinforcement [1]



WHERE does the
concrete industry stand
with graphene?





Current Roadblocks

Three elements must be balanced in order for graphene to become economically viable

COST

- Fabrication
- Cost effectiveness

Solution:

- Life Cycle Analysis
- Physical Research

QUALITY

- Dispersibility
- Effectiveness
- Comprehension

Solution:

- Research & Development

QUANTITY

- Price Sensitivity
- Product Perception
- Fabrication

Solution:

- Sustainability efforts
- Innovation in fabrication



Life Cycle Assessment

LCA will be included as a next step in determining all potential costs and benefits of graphene use

Important Factors to consider for Graphene integration

- Energy Use
- Fabrication
- Natural Resource Consumption
- Cost

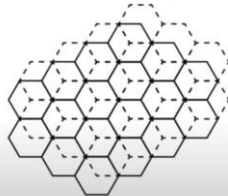




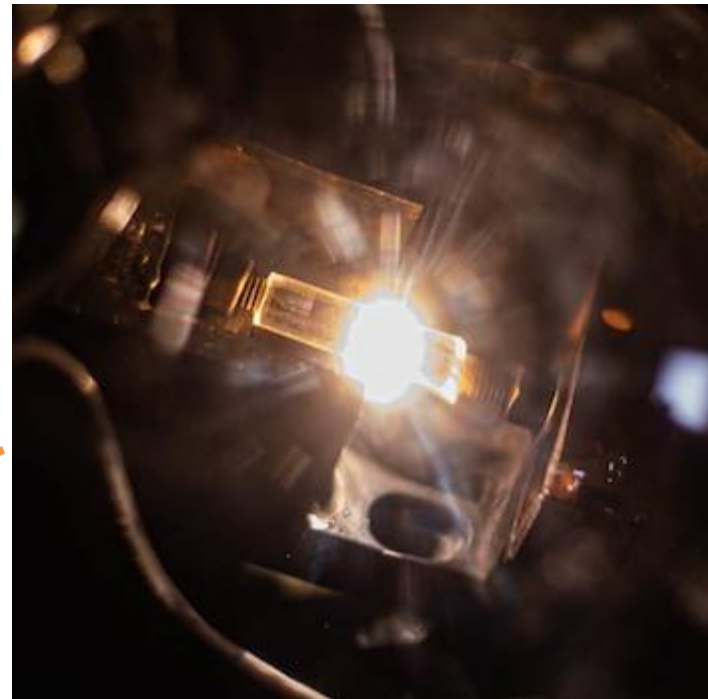
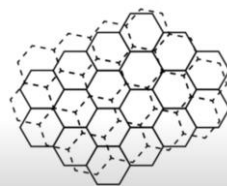
Flash Graphene

- Converts carbon containing waste into pristine graphene
- Heats material to 3000 K in 10 milliseconds [4]
- 0.1% of flash graphene in cement could reduce the environmental impact by a third [4]
- Cost effective

AB - Stacked Graphene



Turbostratic graphene



(Williams, 2020)



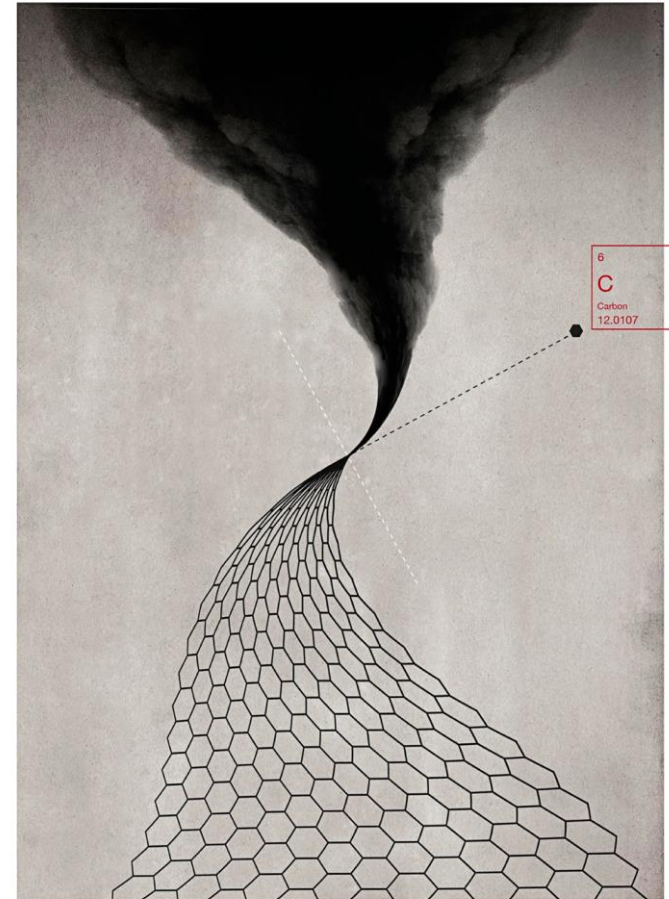
Flash Graphene

\$30 per Ton [7]

**Concentrations as little as .02% of
cement weight [4]**

Increase in Strength by ~35% [4]

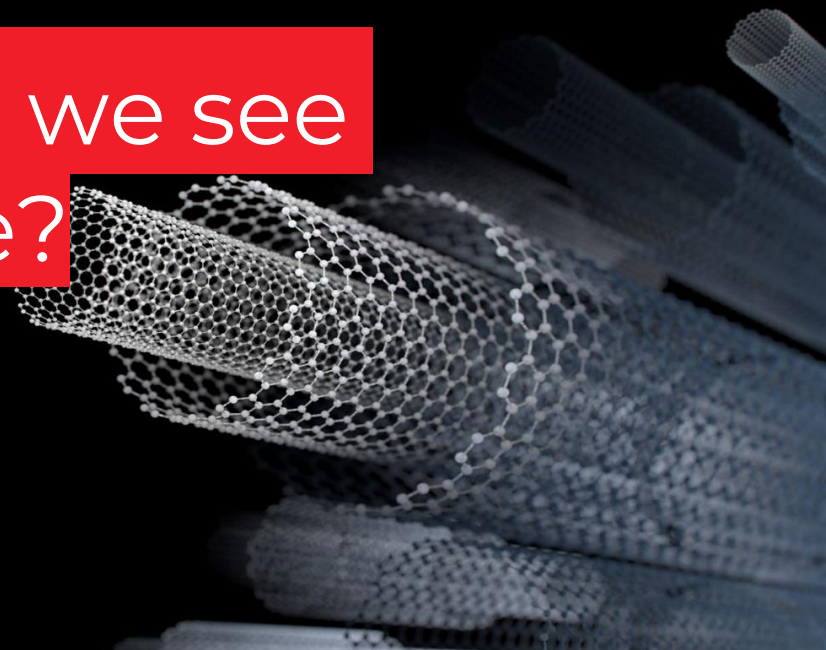
**May use carbon containing solid
wastes [4]**



(Colapinto, 2014)



WHEN can we see
change?





Main Takeaways

**graphene production is
small scale**

**the lack of economic
revenue lowers
motivation**

**The Concrete industry
CAN benefit from
graphene**



Research Statistics

Among all sectors:

Leading driver in research: electronics

- Recent innovations in electronic displays, biomedical, memory chips [5]
- The corporate sector holds 35% of graphene patents
- There is a lag time that appears from discovery to corporate patenting

For the Concrete Industry

- High cost and limited efficiency hinders research and development
- Scalability proves to be a current roadblock





Concluding remarks

1. With an increase in research, a refinement in fabrication, and a higher amount of production, the cost of graphene is expected to decrease in future years [5]
2. Graphene has shown high demand in various fields besides the concrete industry [5]
3. Life Cycle Assessment may assist in the evaluation of graphene integration
4. Flash Joule Heating offers a quick and cheap production method, offering quality products from waste [4]
5. The industry must adapt in infrastructure to proceed with this change



References:

1. *Salami, B. A., Mukhtar, F., Ganiyu, S. A., Adekunle, S., & Saleh, T. A. (2023). Graphene-based concrete: Synthesis strategies and reinforcement mechanisms in graphene-based cementitious composites (part 1). Construction and Building Materials, 396, 132296.* <https://doi.org/10.1016/j.conbuildmat.2023.132296>
2. *The Nobel Prize. (2010, October 5). The Nobel Prize in Physics 2010. Retrieved March 14, 2024, from* <https://www.nobelprize.org/prizes/physics/2010/summary/>.
3. Clark, S. C. (2024, January 16). *Rice study shows coal-based product could replace sand in concrete.* Rice News | News and Media Relations | Rice University. <https://news.rice.edu/news/2024/rice-study-shows-coal-based-product-could-replace-sand-concrete>
4. Williams, J. (2020, January 27). *Rice lab turns trash into valuable graphene in a Flash.* Rice News | News and Media Relations | Rice University. <https://news.rice.edu/news/2020/rice-lab-turns-trash-valuable-graphene-flash>
5. Shapira, P., Youtie, J., & Arora, S. (2012). Early patterns of commercial activity in graphene. *Journal of Nanoparticle Research, 14*(10), 811. <https://doi.org/10.1007/s11051-012-0811-y>
6. Colapinto, J. (2014, December 15). *Material question.* The New Yorker. <https://www.newyorker.com/magazine/2014/12/22/material-question>
7. Agard, S. (2023, May 11). Engineers harness the power of Flash Joule Tech for stronger, Greener Concrete. Interesting Engineering. <https://interestingengineering.com/science/power-of-flash-joule-tech-stronger-greener-concrete>



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THANK YOU

QUESTIONS?

