
Graphene/Polyurethane Laminar Composite for Transparent Armour

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Overview

1. Motivation
 2. Objectives
 3. Technical Approach
 4. Results
 5. Conclusions and Future Work
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Motivation

The problem:

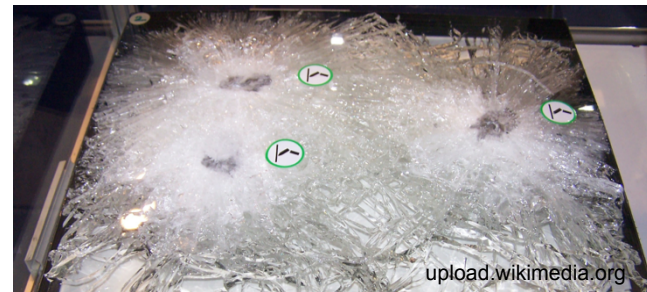
- Current technology cracks and fractures upon impact
- Compromises visibility, decreases the overall strength

The solution:

- Polymers
 - Resistant to crack propagation

Our Idea:

- Graphene-reinforced polyurethane laminated composite
- Lighter and transparent under fire



Objectives

1

Increase impact strength by at least 10%

2

Maintain 90% optical transparency

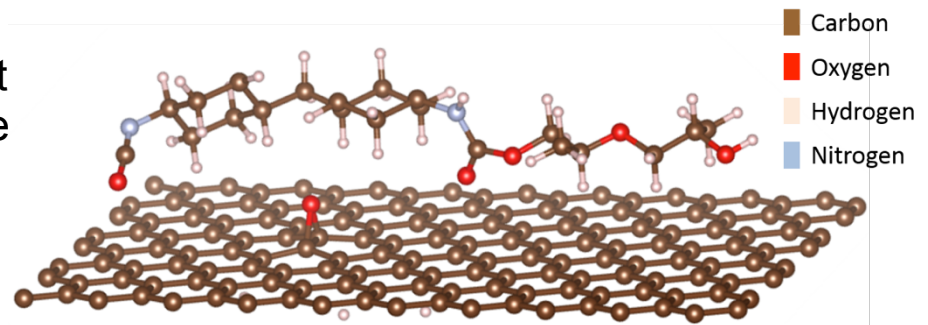
Technical Approach

1. Research
2. Modeling
 - a. Chemical
 - b. Ballistic
3. Fabrication
4. Testing



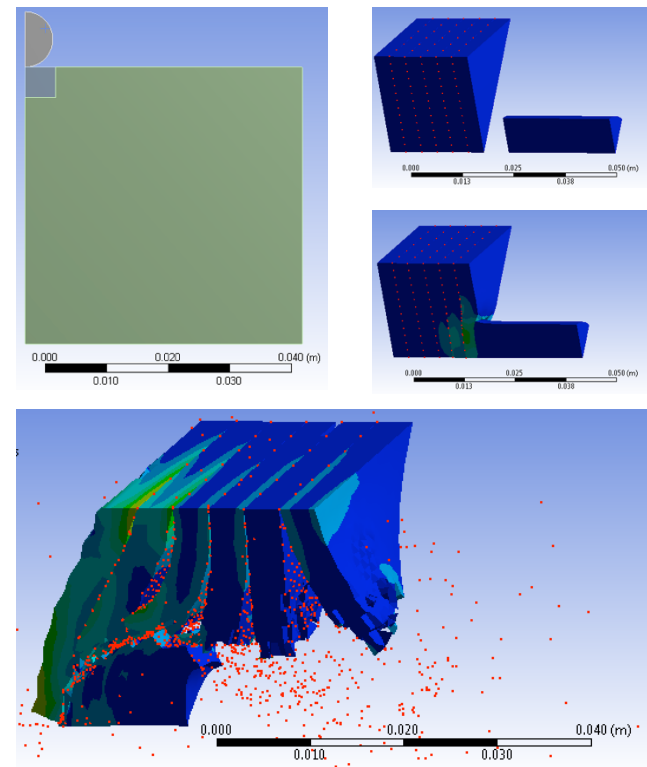
Chemical Modeling

- VESTA
 - Model visualization
 - 3D geometric coordinates
- VASP
 - Multiple bonding simulations to find a molecular spring constant
 - Molecular spring constant relate to elastic modulus through Hooke's Law
- DeepThought
 - Energy minimization
 - Spring constant representing entire system
 - Elastic modulus of the composite



Ballistics Modeling

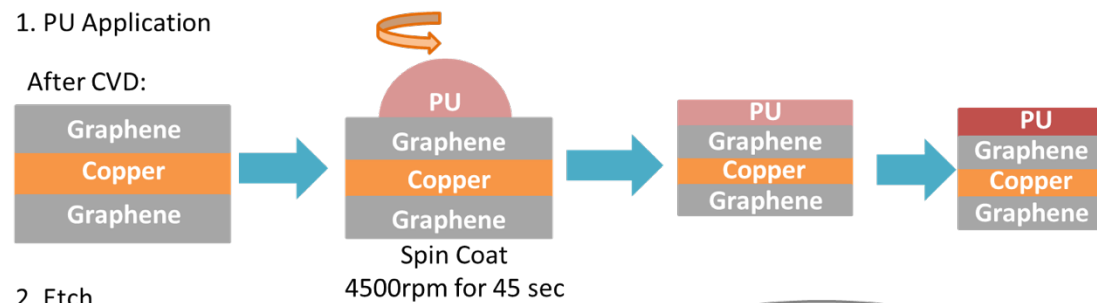
- Hertzian Contact
 - 2D Axisymmetric
 - Penetration depth
- Impact Testing
 - 300 m/s initial velocity
 - Lead cylinder, graphene, and polyurethane composite
 - PU only



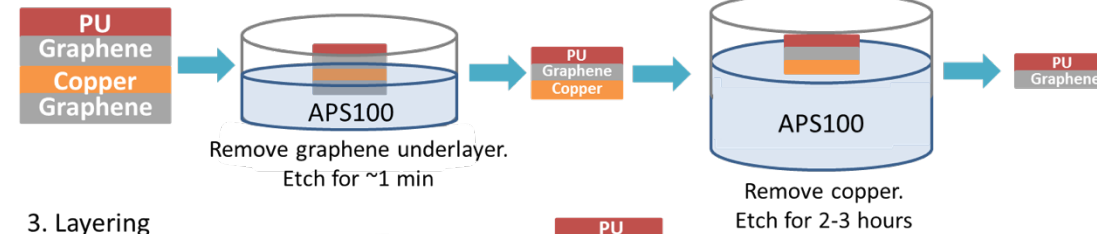
Prototype Fabrication

1. PU Application

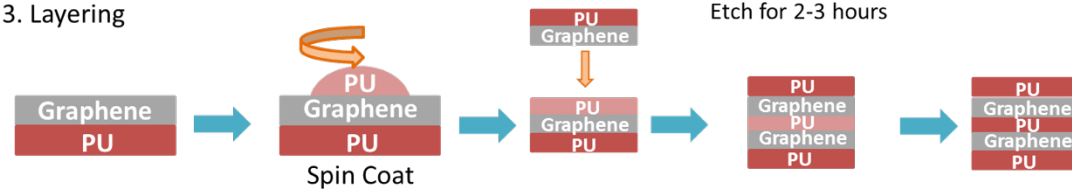
After CVD:



2. Etch



3. Layering



Results

Chemical Modeling

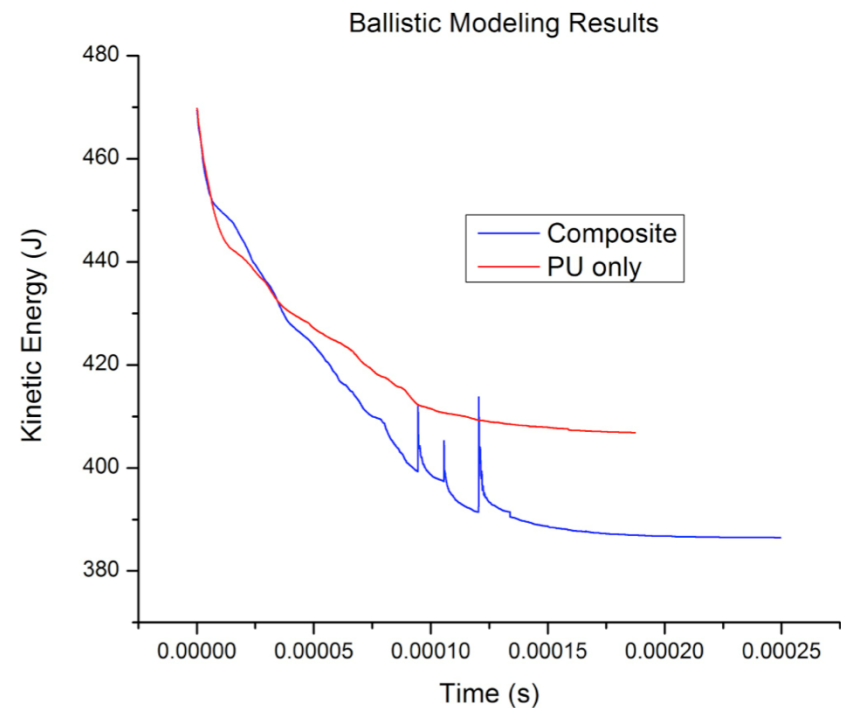
- Edge effects were too large

Ballistics Modeling

- Hertzian: 1.83% error from theoretical
- Impact: 32.4% further reduction in KE with graphene

Fabrication

- Performed CVD to grow graphene
- Tested chemical stability
- Confirmed layer adhesion with newly cast layer



Conclusion

- Composite reduces the kinetic energy and velocity of the bullet compared to PU
 - Developed effective method for lab-scale fabrication
 - CVD, etching, spincoating
 - Promising material combination for transparent armour
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Future Work

- Ballistics Modeling
 - Numerical or experimental method to determine validity
 - Model imperfect graphene and various layer configurations
 - Chemical Modeling
 - Confirm spring constant and elastic modulus
 - Fabrication
 - Test working prototype as proof of concept
 - Lab-scale prototype
 - Scale-up process
 - Meet military standards
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