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PIONEERING ELECTROCHEMISTRY

Colin Fink was a pioneer in electrochemical processing of materials.

Fink is best known for his ground-breaking developments in the electro-deposition of metals, and particularly for establishing how the chromium electrodeposition process influences the resulting material properties.

He developed and patented a commercial process for chromium plating that is, even today, ubiquitously applied throughout the world to create shiny, bright, non-tarnishing, corrosion resistant, hard and durable finishes.

His work not only established the mechanics for chromium electroplating but he also was responsible for developing a process leading to ductile tungsten for incandescent lamp filaments, an insoluble anode used in the copper mining process, and an electrolytic process for the faithful restoration of corroded ancient bronzes. Professor Fink played an active role in The Electrochemical Society, and has been credited with saving the society during the depression.

Many students followed in Professor Fink's footsteps in the field of electrochemistry, including Samuel Ruben. Ruben was associated with both Physics and Chemical Engineering and his invention of the alkaline battery led to the company now known as Duracell. His name lives on at SEAS as an endowed professorship established in his honor.

Engineers throughout Columbia Engineering continue this tradition of excellence in materials science, employing the most advanced tools and theories to develop ever more sophisticated materials.

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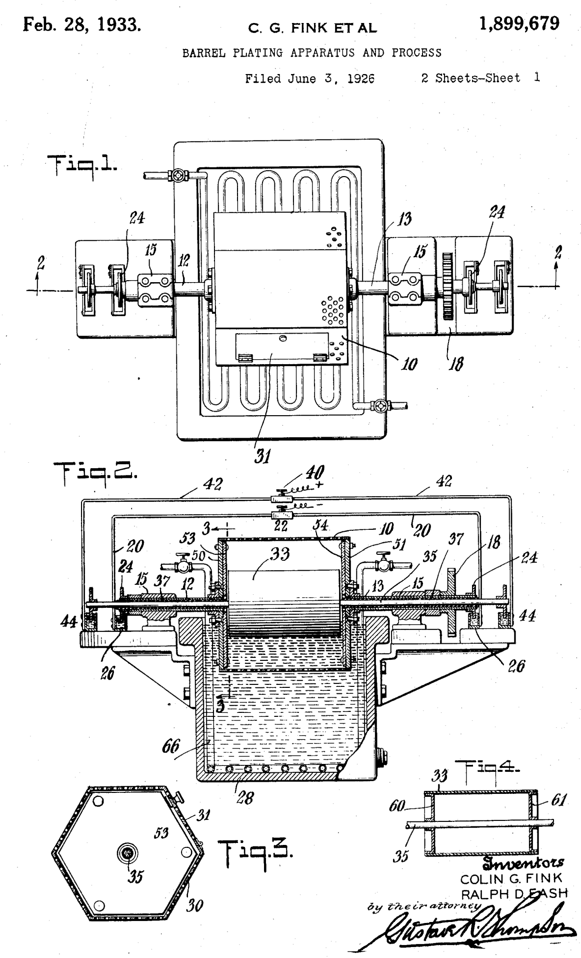
PIONEERING ELECTROCHEMISTRY

Colin G. Fink (1881-1966)

BS’03, ChemE Faculty 1921-50

Developed and patented chromium plating process



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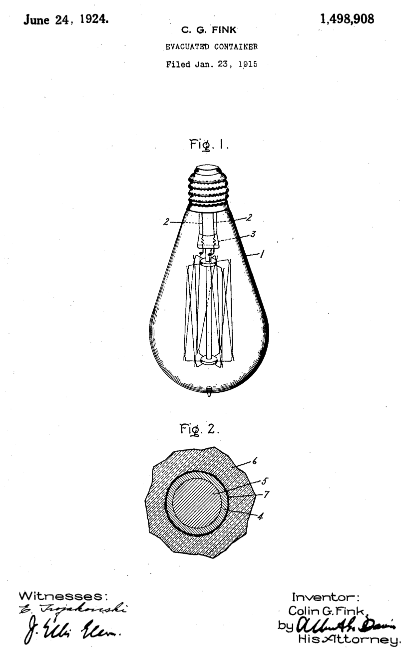
Creates shiny, bright, non-tarnishing, durable finish

Invented process to produce ductile tungsten for incandescent lamp filaments

Taught Samuel Ruben, who invented alkaline battery (Duracell Company)



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COMPUTATION & MATERIALS DISCOVERY

It would be a dramatic understatement to say that a lot has changed since Professor Fink returned to Columbia in 1921 and began his pioneering work. In fact, there was a revolution in physics, whereby we accepted that the long held laws of classical physics cease to work at very small scales, and that the recently discovered elementary particles are governed by the laws of quantum physics. In the past century, we have developed a profound understanding of these new laws, and a current challenge is to now apply these laws with quantitative accuracy and engineer the world around us.

In my research I focuses on predicting materials properties starting from the first-principles of quantum mechanics, including mechanical, magnetic, and electronic properties.

My research efforts include both developing new theories of electronic structure and the application of existing methodologies to understand and design new materials. Executing my research plan hinges upon the use of high performance supercomputers, whose ever increasing power allows us to address higher degrees of complexity every year.

I study a wide range of materials which literally span the entire periodic table, ranging from hydrogen to curium.

In particular, I am interested in materials which have potential applications for energy storage or conversion, such as battery cathodes, nuclear reactor fuels, and thermoelectrics. I also have a strong interest in two-dimensional materials, which give a whole new meaning to the notion of a “thin coating”. While graphene kicked off the revolution of two-dimensional materials, there is now an ever growing library of two-dimensional materials including BN, MoS2, TaS2, phospherene, and many others. Stacking these different two-dimensional materials in various ways could lead to unprecedented properties and novel devices.

We have truly entered a new era, where materials may be designed virtually and fabricated one atomic layer at a time. I am humbled to be part of this great tradition, and very proud to be carrying out this research in SEAS.

COMPUTATION
& MATERIALS DISCOVERY

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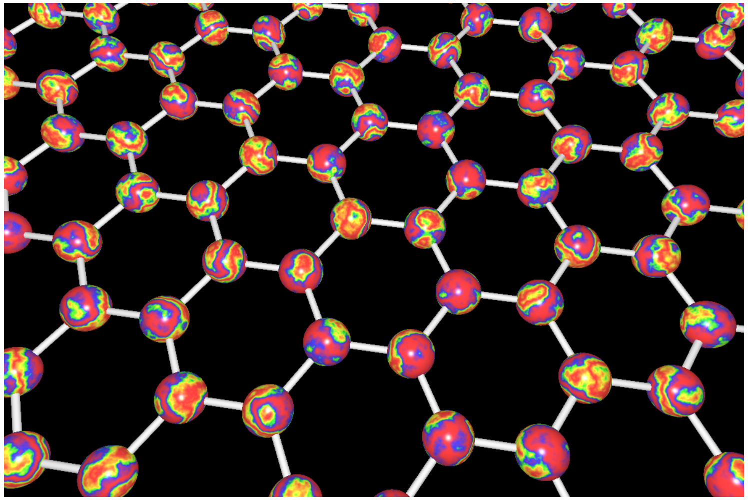
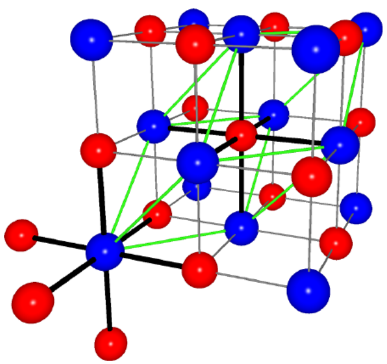
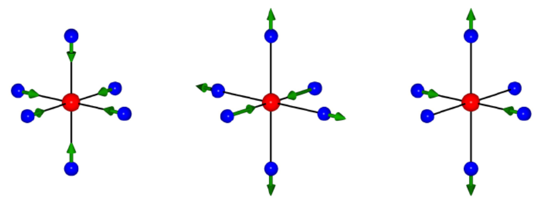
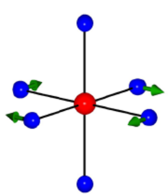
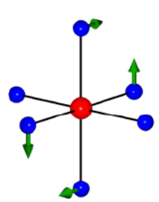
Vision:
Predicting materials properties from first-principles of quantum mechanics

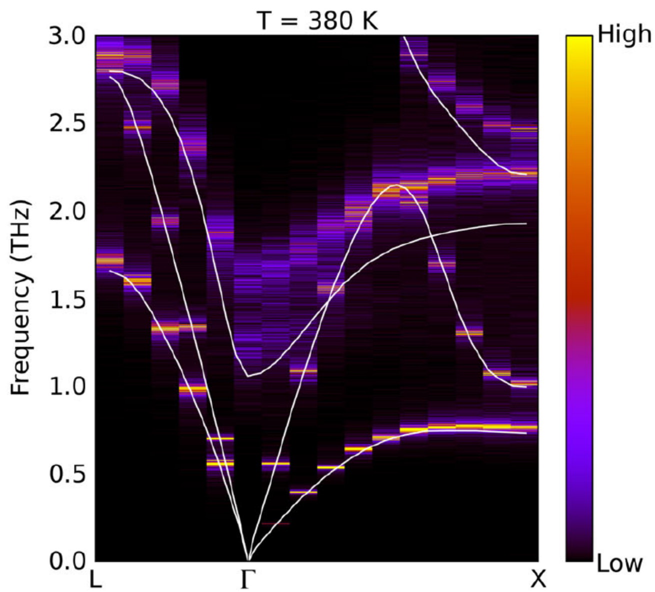


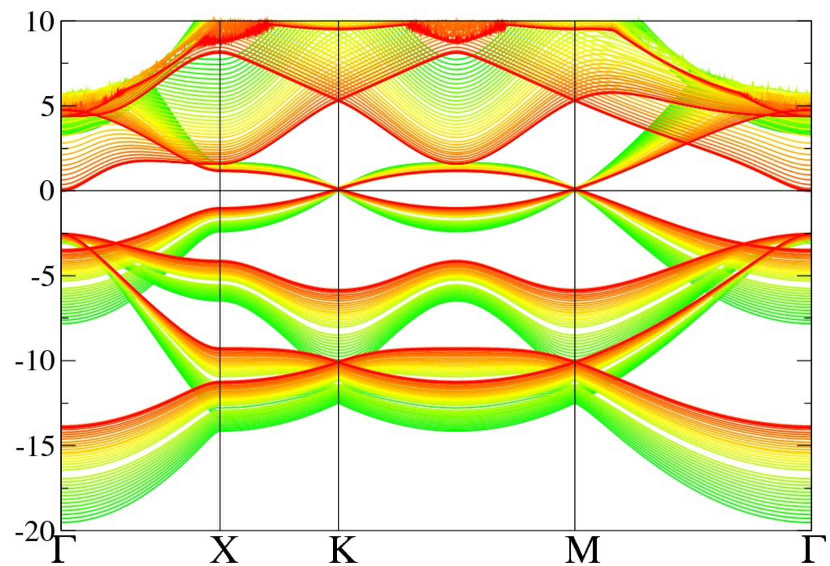












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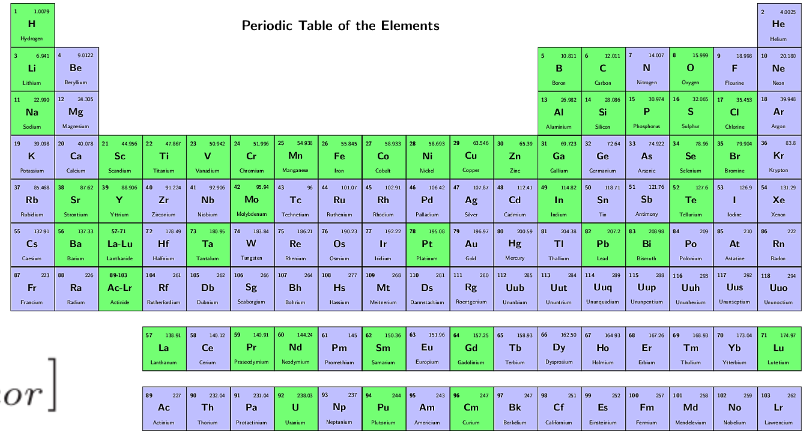
COMPUTATION & MATERIALS DISCOVERY

Vision:
Predicting materials properties from first-principles of quantum mechanics

Approach:
Sophisticated mathematical formalisms & massive supercomputers

$$H = \sum_{\sigma} \int d\mathbf{r} \psi_{\sigma}^{+}(\mathbf{r})[-\tfrac{1}{2}\nabla^2 + V_{ext}(\mathbf{r})]\psi_{\sigma}(\mathbf{r})$$
$$+\frac{1}{2} \sum_{\sigma\sigma'} \int d\mathbf{r} d\mathbf{r}' \psi_{\sigma}^{+}(\mathbf{r})\psi_{\sigma'}^{+}(\mathbf{r}')\frac{1}{|r-r'|}\psi_{\sigma'}(\mathbf{r}')\psi_{\sigma}(\mathbf{r})$$



$$\Gamma[\rho, G_{cor}; V^{Hxc}, \Sigma] = \mathrm{Tr}\,[\ln G] + \Phi[\rho, G_{cor}]$$
$$-\mathrm{Tr}[V^{Hxc}\rho] - \mathrm{Tr}[\Sigma_{cor} G_{cor}]$$

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COMPUTATION & MATERIALS DISCOVERY

Vision:
Predicting materials properties from first-principles of quantum mechanics

Approach:
Sophisticated mathematical formalisms & massive supercomputers

Impact:
New materials for energy storage & conversion (battery cathodes, nuclear reactor fuels, thermo-electrics), & with novel functionality for device applica-tions (ferromagnets, ferroelectrics, etc).