Closer Look

MEMORANDUM

Executive Highlights

- Google was granted a patent in March for a method by which a reader would power its glucose-sensing smart contact lens and extract data to a user interface.
- The recency of the patent filing (filed in November, approved in March) is encouraging and indicates continued interest and work on the diabetes application of the project with partner Novartis.

Google was granted a patent in March related to communication between its glucose-sensing contact lens and an external reader/display device. The filling was submitted to the US Patent and Trademark Office in November 2014, reflecting an agency review of five months. The full patent makes 154 references to "glucose," and from it, we learned some new tidbits about the potential smart contact lens design (see images here). Most notably:

- An external reader device would power the smart contact lens and collect data from it - the patent discusses a spectrum of possibilities, including jewelry, eyeglasses (e.g., Google Glass), clothing, or a mobile phone;
- The reader could power the lens via RFID, though a solar-powered lens is also mentioned;
- There are mentions of alarm protocols/displays, suggesting that a CGM-like application of the technology is possible;
- The lens could use glucose oxidase to measure glucose, similar to current CGM offerings;
- Impressively, the smart contact lens could have dimensions on the order of those used in corrective lenses: a diameter of ~1 cm and a thickness of ~0.1-0.5 mm.
- The smart contact lens could measure a variety of substrates and biometrics in addition to glucose, including lactate, proteins, lipids, and temperature;

Of course, the patent filing does not necessarily reflect the company's (or partner Novartis') most updated plan for product design. However, it is broadly instructive, and certainly the most specific detail we've heard on the design of the glucose-sensing contact lens. This project has been fairly stealth since the Novartis licensing deal was announced last July.

Novartis' 4Q14 references to the smart contact lens project seemed to shift a bit away from the diabetes application towards broader ophthalmologic indications; management only referred to the "accommodating lens" project, which (as we understand it) refers to the lens application for presbyopia and myopia. The recency of this patent filing indicates that the diabetes application is still under development and certainly an active area of interest.

From a patient perspective, this approach could offer some compelling discretion - a glucose sensing contact lens powered by clothing/jewelry/glasses, with data sent to a mobile phone interface! Of course, there are still challenges to overcome, including accuracy, reliability, calibration, and cost-effectively manufacturing such a sensor at scale. But we continue to be optimistic, especially given the collective brainpower at Google and eye expert Novartis (Alcon).

Below, we share more on the most interesting learnings on the smart contact lens design:

- **Based on the patent filing, the smart contact lens system could function as follows:** (i) an external reader would power the smart contact lens; (ii) the lens would measure glucose via an

embedded sensor; (iii) the reader would extract glucose measurements from the sensor and store/ send the glucose data to a user interface. The patent suggests the reader and display device could be one in the same (e.g., glasses), or two different devices (e.g., a piece of jewelry as the reader and a mobile phone as the interface).

- **The reader could be a computer, mobile phone, a wearable device, a pair of eyeglasses, jewelry (e.g., earrings, necklace), a headband, a hat, other clothing (e.g., a scarf), and/or other devices.** The primary criteria is that the reader must frequently be in close enough proximity to one or more of the lenses to ensure the lens has a reliable external power source and storage for sensor data collection. From a convenience perspective alone, some of these reader concepts would be a major win for patients - potentially no need to carry around an extra device, significant discretion, and high "cool factor."
    - **As we understand it, the reader could power the lens via a radio frequency identification (RFID) protocol**, though other possibilities are also discussed (including a solar-powered lens!). Communication between the reader and a potentially separate display device is likely to use Bluetooth, though again, the document acknowledges multiple other communication protocols under consideration (WiFi, 4G, etc.).
- **The display device could be any type of mobile or wearable computer.** One example given is a head-mountable display (HMD) that is defined as "a device that is capable of being worn on the head and places a display in front of one or both eyes of the wearer." Of course, Google Glass springs immediately to mind, another project in the Google[x] division. We assume that such a display could function as both a reader and user interface, consolidating and simplifying the necessary communication protocols.
- **The patent also makes specific mention of alarm protocols/displays, suggesting that Google's ultimate goal may be a CGM-like application of the technology.** This is not particularly surprising - and is largely consistent with rumors we have heard previously - but it is very neat to see confirmation of how Google is thinking about it. Of course, another approach to the lens is more of a FreeStyle Libre-like "scan" of the contact lens with a reader device (non-continuous data transfer) - we assume both design possibilities are possible.
- **The patent mentions glucose oxidase, meaning the actual sensor chemistry could resemble current CGM offerings from Medtronic, Dexcom, and Abbott.** The sensor itself would be embedded near the periphery of the lens to minimize interference with light transmission to the central, light-sensitive region of the eye. One possibility is a ring-shaped design that would encircle the cornea.
- **Regarding the detection of glucose in tear fluid, the document indirectly addresses criticisms that such measurements may not be reliable:** "The biomarker concentrations in the tear film can be systematically different than the corresponding concentrations of the biomarkers in the blood, but a relationship between the two concentration levels can be established to map tear film biomarker concentration values to blood concentration levels. For example, the tear film concentration of glucose can be established (e.g., empirically determined) to be approximately one tenth the corresponding blood glucose concentration."
    - **The feasibility of glucose sensing in tear fluid has been a criticism of the lens,** and we look forward to better understanding how the lens will accurately measure glucose at levels one-tenth of the blood concentration. We did not find specific details in the patent on this front..
- **The smart contact lens could measure a variety of substrates and biometrics in addition to glucose.** These will include organic (e.g., lactate, proteins, lipids) and inorganic (e.g., Ca^{2+}, M^{2+}, Cl^{-}) components. Google also received a slew of other patents related to the contact lens in the past month, including applications to pulse oximetry, ocular hydration level, and temperature sensing. This brings potential to create a widely applicable diagnostic tool.

- **Impressively, it appears that the smart contact lens will have dimensions on the order of those used in corrective lenses:** a diameter of ~1 cm and a thickness of ~0.1-0.5 mm (though this would vary between patients). The document also mentions a "deformable" material, suggesting that the lens: (i) can be constructed from material already employed in commercial contact lenses; and (ii) would likely be very similar to the "soft" contact lenses that most consumers are already familiar with. We assume the expertise of partner Novartis' Alcon division will be invaluable on this front.

-- by Varun Iyengar, Adam Brown, and Kelly Close